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TABLE OF CONTENTS.

LEADING ARTICLES:	Page.
Notes on the Quebec Bridge Competition.—I. (illustrated); Gustav Lindenthal, M. Am. Soc. C. E.	581
The Repair of a 9,500-Ft. Leaky Steel Plate Pipe Line at Boulder, Colo., by Oxy-Acetylene Welding (illustrated); Louis Elliott.	586
Dry-Dock at Port Arthur, Ont., Canada (illustrated); A. V. Powell, M. Am. Soc. C. E.	588
A Speed-Reduction Gear and Transmission Dynamometer (illustrated)	591
Comparative Merits of Cast-Iron and Steel Pipe; Nicholas S. Hill, Jr.	593
The Design of Masonry Dams: Should Hydrostatic Pressure Underneath and Ice Pressure be Included (illustrated); Edward Wegman	594
The Maximum Dimensions of Ships; Sir Wm. H. White	595
A Report on an Underground Rapid Transit System for Chicago (illustrated)	602
Paving Over Gas Mains and Capitalization of Profitable Contracts as Elements in Rate Making: Decisions of the New York Public Service Commission in the Kings County Lighting Case	604
A Locomotive Crane Mounted on a Gantry to Serve Both Sides of a Pier (illustrated)	605
Alloys; W. R. Whitney, Past Pres. Am. Chem. Soc.	606
An Inclined Deep-Well Pump Used to Take Water from a River Having Great Variations in Level (illustrated)	607
A Device for Increasing the Capacity of Rotary Driers for Granular Materials (illustrated)	607
Model Housing Plans for the Philippines (illustrated); Geo. H. Guerdrum	608
Inland Waterways and Waterway Projects in France	609
EDITORIALS	599
Mr. Lindenthal on the Quebec Bridge Competition—The Most Powerful Engine in the World—An Authoritative Opinion on the Increase in Size of Ships—Storage Reservoirs for River Regulation in Western Pennsylvania—Speaking Up for the Engineering Profession.	
An Offer of Free Highway Bridge Engineering Work by a Federal Bureau	600
LETTERS TO THE EDITOR	601
Practice in Branding Cement; Kennedy Stinson—Freight Steamers Equipped with Conveying Apparatus; Babcock & Penton—Why Not Open the Door for Promotion to U. S. Assistant Engineers Now in the Service? E.—An Automatic Sluice Gate for Spillway Crests; Eugene Lauchli.	
ENGINEERING NEWS OF THE WEEK	611
PERSONALS	612
ENGINEERING SOCIETIES	612
ENGINEERING LITERATURE SUPPLEMENT	37

Notes on the Quebec Bridge Competition.—I.

By GUSTAV LINDENTHAL,* M. Am. Soc. C. E.

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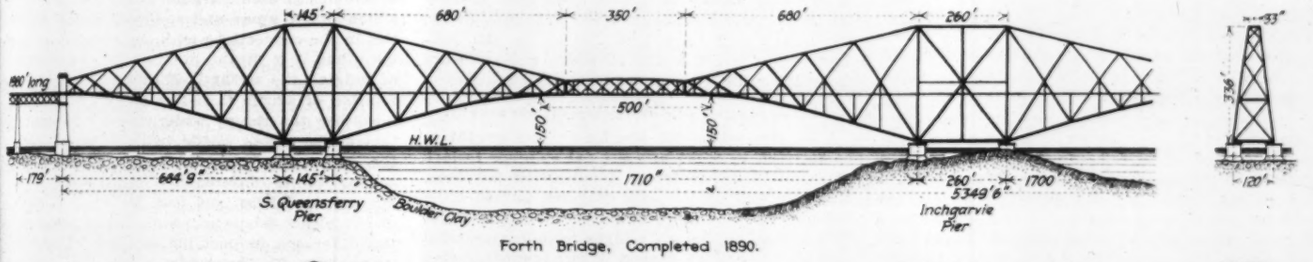
The Quebec Bridge over the St. Lawrence River will have the longest span so far built and for that reason principally has engaged the deep interest of engineers for many years. When, after many years of agitation, its construction neared realization, the project was expected to be studied and prepared in the best manner and creditably to present-day knowledge of bridge architecture. That this expectation was not fulfilled in the first attempt, that a horrible disaster occurred, and that in the second attempt (when completed on the reputed present plans) posterity will behold a structure inferior (considering present resources) to the Forth Bridge, nearest in length of span, built 25 years ago, are all matters of deep regret, particularly to American engineers.

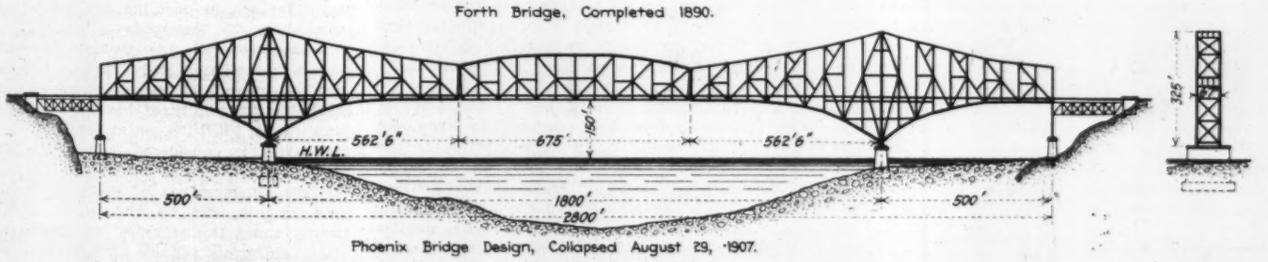
The location of the bridge is seven miles above Quebec, where the wide and tidal river narrows to a width of 2,000 ft., with a depth of over 150 ft. The steep shores on both sides, 150 to 180 ft. high, are admirably suited for bridge approaches, while a submarine tunnel is out of the question because of the great depth of water.

The first plans were proposed in 1852 by the late General E. W. Serrell. They were for a stiffened iron-wire suspension bridge to carry a wagon road and railroad tracks, a very bold design for those early days. Later, in 1885, plans for a cantilever structure were made by

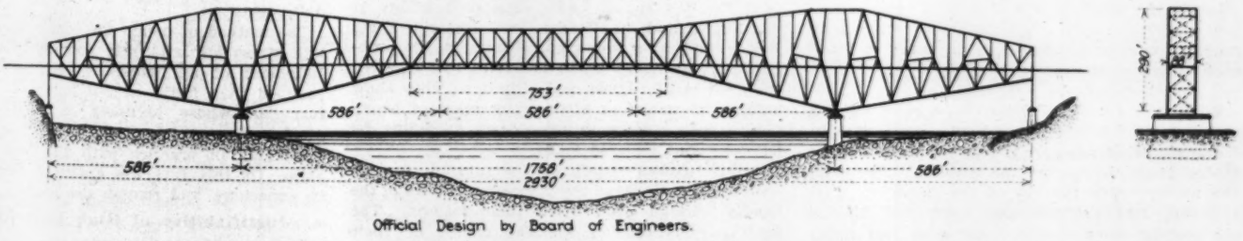
*Consulting Engineer, 45 Cedar St., New York City.



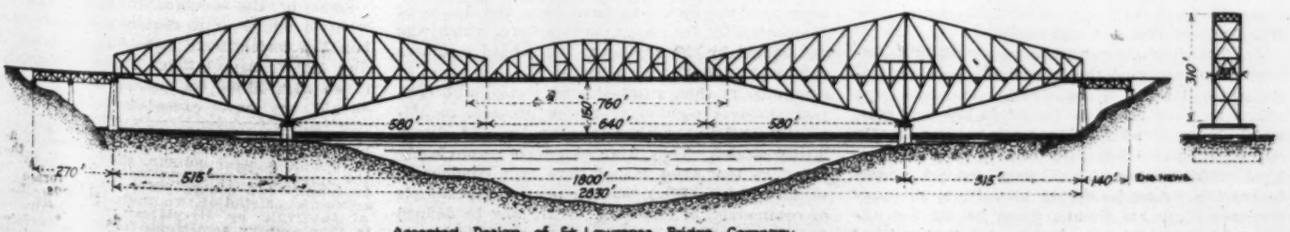
Forth Bridge, Completed 1890.



Phoenix Bridge Design, Collapsed August 29, 1907.



Official Design by Board of Engineers.



Accepted Design of St. Lawrence Bridge Company.

FIG. 1. CANTILEVER BRIDGE DESIGNS: THE FORTH BRIDGE AND THREE QUEBEC DESIGNS.

James Brunlees and T. Claxton Fidler, of London (published in London Engineering, April 3, 1885). But the country was as yet not rich enough to assume the financial burden of such a large work. A serious beginning was only made fifteen years later by the Quebec Bridge Co., specially chartered by the Canadian Government.

In 1899 that company invited competitive plans from American and Canadian bridge-building firms, on the basis of general specifications for a structure to carry a double-track railroad with a wagon road and trolley line on each side. The live-load was 6,000 lbs. per lin. ft. of bridge, for the trusses, with the usual concentrations for the floor system. Six plans were submitted by five firms. Four plans were for cantilever structures and two for suspension bridges; but one suspension design, a combination of wire cables and trusses, was excluded as too weak and not in compliance with the specifications.

The Phoenix Design.

The Phoenix Bridge Co. had submitted two designs, one for a cantilever structure, prepared by its own staff of engineers, and one for a rigid suspension bridge, prepared for that company by the writer (see Transactions Am. Soc. C. E., Vol. LV., p. 3; also Prof. Melan's work, "Theorie der eisernen Bogen und Hängebrücken," p. 162). The Phoenix company's cantilever plan was claimed to be lowest in price, and for that reason was chosen for execution.

After a delay of some years, caused by financial difficulties, the construction was commenced, and it had proceeded to the erection of one-half of the structure when, on Aug. 29, 1907, the bridge collapsed under its own weight, with a loss of 80 lives and four million dollars in property destroyed. That catastrophe came as a great shock to the public and was justly regarded as discreditable to American bridge engineering.

The only parallel in magnitude to that disaster in the history of bridge construction is the collapse of the Firth of Tay Bridge in Scotland on Dec. 28, 1879, during a gale, when the upper part of the piers, consisting of braced cast-iron columns, crumbled under the wind pressure and let the truss superstructure and an entire passenger train fall into deep water, with a loss of 90 lives and over three million dollars.

CAUSES OF DISASTER.—The primary cause of both disasters was the same: bad engineering. But in connection with the Quebec Bridge was a contributory circumstance of which it is difficult for engineers to speak without a feeling of humiliation, and that is the beggarly compensation for engineering services on a work of unprecedented magnitude and the willingness of an engineer of high reputation and unimpeachable integrity to assume very important and laborious duties for a fee for which they could not possibly and seriously be met.

It sometimes happens that the financial condition of a company during the incubation of large work is weak, and that the engineer and other professional men aiding in its promotion are satisfied, quite properly, to receive only nominal compensation for their services, until such time as the undertaking shall be financed and everybody can be fully paid.

While the Quebec Bridge Co. was struggling along, it could not pay more than a small amount for engineering advice. It got its plans for the bridge from contractors for nothing. But after the money, with the aid of the Canadian Government, was assured, the large and difficult engineering work should have been thoroughly taken in hand, through an efficient engineering organization, properly compensated.

Mr. Theodore Cooper, who as Consulting Engineer had assumed the largest share of responsibility, had no such organization and could not afford to have it. The fee of $3,750 per year, which he received for his services, was hardly enough to pay office rent and a stenographer. Most unfortunately Mr. Cooper seemed unable to see the wrong he did to himself, to the profession and to his clients, when he did not advise and explain to the last-named that neither he nor any other engineer could conscientiously undertake the important duties without adequate facilities and a competent working staff, and that the compensation should be made sufficient both for his own services and theirs. His action was a grievous wrong to the engineering profession, as it tended to create the impression that responsible engineering service was of little account and could be had for next to nothing, provided contractors' plans were furnished.

It is most pathetic to notice from the testimony how Mr. Cooper endeavored to serve his employers faithfully, unselfishly but mistakenly. With a proper engineering organization it would not have been necessary to rely in any degree upon the office work and strain sheets of the contractors. Entirely independent computations could and should have been made by the responsible engineer, and the errors in the assumption of dead-load would have been discovered before construction began. Systematic study and analysis could also have been given to the contractor's design to determine whether and where modifications in form and details, as for instance in the compression members, must be made for greater safety.

These thoughts, as here mentioned with the kindliest spirit to Mr. Theodore Cooper, an old and valued friend, are more particularly intended to call attention to a most essential requirement of good engineering service on large work, and that is resolute and great executive ability, which is rarer even than great technical ability. The failure of everyone concerned to recognize the importance of that requisite in the engineer's work contributed greatly to the failure of the bridge.

When the sinister aspect of engineering in the old bridge is compared with the subsequent lavish expenditure of hundreds of thousands of dollars for engineering services for the new bridge—which were of no value, and which produced only wasteful plans that were finally laid aside for a contractor's plan furnished gratis—we might wonder at all this, were the public not accustomed to a pusillanimity in the conduct of our public works of which engineers are more often the victims than the instruments.

The Strength of Compression Members.

After the bridge fell the blame was sought to be ascribed by some professional opinions to lack of scientific knowledge of compression members, which it was alleged can only be derived from full-size tests of large columns. We should not forget that big metal bridges with compression members relatively larger, when manufacturing resources are compared, were safely built when that kind of knowledge from tests was much less than at the time of the disaster.

It is not necessary to make full-size tests of very large compression members. The large cost of such tests would be in no proportion to the benefits derived. Such members can be safely proportioned without such costly tests, by using with skill and good judgment the knowledge already at hand derived from tests with smaller compression members. In Brunel's large bridge over the Saltash, in Ead's steel arch bridge at St. Louis, and in Fowler and Baker's Forth Bridge, and other important structures, the problem of large compression members had received the most careful study and attention. They show no sign of weakness after many years of heavy traffic, with loading in some cases exceeding by 50% the contemplated loads.

But no studies of any kind were made for the unprecedentedly large compression members of the Quebec Bridge until after their failure. The leading consideration for the choice of their cross-sections seems to have been the desire of the contractor for cheap manufacture, which was not balked by the engineer. The chord members consisted each of four slabs or ribs composed of a number of thin, stitch-riveted plates, with contact surfaces painted or rather greased, insufficiently stiffened with flange angles and flimsy lattice angles. They were of a form so obviously defective that they should have been condemned at first sight. They were a pernicious example of commercial engineering, which may be defined for this case as the subordination of design to the cheapest methods of manufacture, under the pretense of fulfilling specifications. These cannot, of course, cover everything and cannot dispense with the guiding judgment of the responsible engineer.

It is doubtful whether anybody would have been convicted for those defective compression members. They complied strictly with the specifications, as commonly interpreted. It is even more doubtful whether any engineer, condemning those members against the opinion of the Consulting Engineer and the bridge company before the bridge fell, would have been listened to in the absence of any tests to prove the negative.

It is one of the most curious delusions in applied mechanics that the relation of l/r in the various compression formulas can be assumed to apply without discrimination to all kinds and compositions of column sections—to solid, to annular and to open sections—and that for all of them the same strength is claimed, provided only that they have the same radius of gyration and the same length.

If this were so, then a column made up of 24 plates each ½-in. thick, 12 ins. wide, lubricated along their contact surfaces and bolted together, should be as strong as a solid column 12 x 12 ins.

Can it be claimed that the bottom chord (of four slabs of thin plates) which failed, should be as strong as a steel tube of 60-in. diameter and solid wall 4½ ins. thick—see Fig. 1 herewith—simply because both have the same cross-sections (780 sq. ins.) and the same radius of gyration (19.7 ins.) and the same length? According to the current interpretation of the compression formulas in use it should be so; but where is the proof?*

The bottom chord failed suddenly and without warning at 16,800 lbs. per sq. in., whereas it was expected that it would fail (as a steel tube would) at about 30,000 lbs. by gradual bending and giving ample warning. This, of course, is not meant as an argument for the tube form, which offers great and well understood difficulties in the connections with the other truss members, but it is meant to point out the absurdity of judging the strength of columns solely by the relation of length to radius of gyration.

Neither the theory underlying all column formulas nor tests made with columns justify the pretense of scientific accuracy which goes so far as to differentiate compressional unit-stresses by 50 lbs. and less, for small variations of l/r, nicely tabulated; while in the actual tests the difference in buckling strength of such columns may be thousands of pounds. Contrast this practice with the method of dimensioning tension members, more particularly eyebars, where thousands of tests have shown a most remarkable uniformity of behavior. Here a stepping off by 1,000 lbs. or at most 500 lbs. in the unit-stress is considered quite proper and correct; from which it might be concluded that compression members, of whose behavior we are least certain, can be dimensioned with ten to twenty times the accuracy for tension members, whose uniformly reliable strength is known from daily tests.

The method of using, for compression, a round unit-stress low and safe enough in the trained judgment of the engineer, seems to be better justified than faith without judgment in column formulas whose accuracy is dependent upon nicely adjusted laboratory conditions, not fully attainable in practice with the best workmanship. Of this fact the engineer should always be conscious, and remain the judge.

Justifiability of High Unit-Stresses.

Some of the columns in the Quebec Bridge were so tender as to require great care to avoid bending under their own weight during handling and transportation. For that form, which failed with 16,800 lbs. per sq. in., the unit-stress should not have exceeded 8,000. But if the

*The recent disaster with a gasholder in Hamburg, Germany, which collapsed because of the failure of a steel column, shows how general is the improper interpretation of column formulas to justify bad design for commercial ends. The column consisted of two angle-irons held together at intervals by tie-plates; a defective form, in this country sometimes found in fraudulently-built country road bridges. Yet in the Hamburg case, Euler's column formula was seriously cited as proof of its correct design.

trusses in a span of 1,800 ft. were dimensioned on anything like that basis, the bridge would have required about four times as much steel (about 300 million pounds).

Every bridge engineer knows that an increase in the engine and train loads over those originally assumed for an existing metal bridge reduces the margin of safety very much more in all those members in which the live-load stresses are greater than the dead-load stresses (as for instance in suspenders or in the floor) than in truss members in which the reverse proportion of stresses exist, as is the case when trusses are over 500 ft. in length. High unit-stresses in the trusses of long spans are therefore justified and permissible; and in the trusses of very long spans absolutely necessary. Otherwise the great preponderance of the dead-load would produce monstrosities of prohibitive cost.

But the use of high unit-stresses requires searching care and good judgment. It is most important that the dead-load shall be computed with accuracy and repeatedly checked during the development of the design for each part of the structure. Errors in the assumption of the dead-load may cause fatal consequences, as they did in the Quebec Bridge, or may result in permanent weakness, as in the Blackwell's Island Bridge. A similar error in ordinary spans involves no such great risk. Nor can great errors arise in long spans any more than in short spans from the live-load and wind stresses, because these are, in statically determinate systems as in the Quebec Bridge, computable with reliable accuracy on first assumptions.

Only in statically indeterminate structures may repeated calculations of live-load stresses be necessary, aside from the usual check calculations to guard against arithmetical errors, which must be made of every computation.

Royal Commission of Engineers Succeeded by Board of Engineers to Design New Bridge.

The fall of the cantilever bridge was investigated by a Royal Commission of three very conscientious Canadian engineers, who made an exhaustive and able report to the Minister of Railways and Canals. From the experience gained in this investigation it might have been assumed that this Commission would be particularly well fitted to prepare the groundwork and to prescribe the conditions to be fulfilled in the plans for a new bridge. That requires a willingness to listen and investigate before making a decision, besides sound technical judgment of the larger kind, rather than minute expert knowledge which can always be procured when needed.

But the Canadian Government chose to throw away the valuable aid of that Commission, and to appoint another Board, of three engineers, one from Canada, one from the United States and one from England, to make a design for a new bridge. The fact of their residing far apart made constant consultation and cooperation, which is imperatively necessary for the working out of a plan, difficult if not possible; a fact to which the attention of the appointing power should have been called at the time, but seemingly was not, by the engineers themselves. (Later on the English member resigned before tenders were received.)

It is one thing to lay down general rules and specifications for a large structure and an entirely different thing to work out a design. The first can be done by a Board or Commission quite well; but the second cannot be done that way satisfactorily. If a bona fide competition was desired, then it should have been invited from a number of firms or designers to whom at least the actual expense of making the plans for such an unusual structure should have been paid. This is a just and recognized practice in architectural competitions.

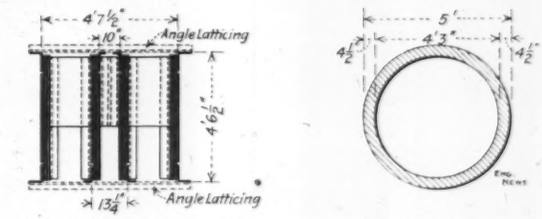
But whether the design be selected in one way or the other, there is the further important condition to be observed that the responsibility for the execution of the work should be one-man responsibility. Diffusion of engineering direction and authority lessens the sense of responsibility. It was so with the collapsed bridge.

Boards and Commissions are useful for deliberation. They may examine, advise, judge, criticise or approve, all of which is important, but a Board is not suited for the actual plotting and working out of details or for the daily direction of construction work. This is executive work which, as experience teaches, can most effectively be done only under a single responsible head. The most prominent present example is the construction of the Panama Canal, the high efficiency of its direction under a single head being universally recognized.

Invitation of Competitive Designs; Remarkable Conditions of This Invitation.

The Board after much labor and time brought forth minute specifications and an official design called the Board's Design (with several variations of trivial importance), on which tenders were invited from bridge construction companies. With feigned impartiality these companies were also invited to submit designs of their own, if they desired to do so, also with tenders thereon. The Board's Design was for a cantilever structure, carrying a double-track railroad and two wagon roads and trolley lines, the same as for the collapsed bridge but for a greater live-load.

The preparation of that design cost the Canadian Government about $500,000 and 2½ years' time. But the bridge companies were expected to make their competitive designs without compensation and in four months' time. If five or more of the world's bridge firms had been invited to prepare competitive designs, on a proper general specification, in six months' time, and for a compensation to cover expenses, then at 20% of the cost of the official design (which afterwards was ignored) and in less than one-quarter of the time there would have been a choice from a number of superior plans with tenders thereon, which would have represented the best practice and advance in the art.



Cross Section of Bottom Chord in Quebec Bridge (780 sq. ins.)

Rad. of Gyration parallel to Latticing = 19.7. Buckled Sideways with 16,800 lbs. per sq. inch.

Tubular Section. (780 sq. ins.)

Rad. of Gyration = 19.7. Probable Buckling Strength 30,000 lbs. per sq. inch.

FIG. 1. THE PHOENIX QUEBEC COMPRESSION CHORD AND A TUBULAR SECTION OF SAME AREA AND SAME RADIUS OF GYRATION.

Fairness required that all designs invited by this Board, including its own, should, if need be, on its own motion, be subject to scrutiny and decision by a special and unbiased commission of engineers. The impression prevailed, not unnaturally, that the Board would be prejudiced against other designs but its own. In fact the specifications were pointed to as proof of bias. But as it was, the same Board responsible for the official design (with only one member out of three changed) was and presumed to be also the judge of the designs competing with it. How much or how little confidence that Board or its majority, which had prepared and adopted the official plan, had in its own qualification may be gaged by the fact that it required its own design, which presumably represented its best collective wisdom, to be guaranteed by the contractor, who had to assume under Par. 5 of the specifications *"the entire responsibility not only for the materials and construction of the bridge, but also for the design, calculations, plans and specifications and for the sufficiency of the bridge for the loads therein specified."*

One may wonder why under such conditons the Board should consist of engineers at all. What confidence could a body deserve or command, which having been under no limitations for engineering expenses or for time in making plans, was still so doubtful about them as to avoid responsibility, which it placed wholly upon the bidders, who had not been consulted about the plans, who had no share in making them or a voice in selecting the engineers that made them?

The psychology of that provision, of course, is not hard to understand. The old bridge fell down; it was the fault of the engineers. Engineers are irresponsible; they have no wealth. They cannot respond in damages, but the contractor can, so if he is anxious enough for the contract and the profit from it, put the whole thing on him. What a conception of professional duty, honor and dignity for engineers!

It is quite true that the contractor has and should have the sole responsibility for the erection of the structure, as the erection, once its method is decided on and approved by the engineer, depends largely on the management and organization of his own forces and appliances. But this responsibility is sharply distinguished from that for the design and for the strength and safety of the bridge and for its erectability. This should be wholly the responsibility of the engineer.

While thus the contractor has a responsibility placed upon him under the specifications and contract which should not be his, there are some strange provisions in them which put power into the contractor's hands which he should not have. Under Par. 113, certain *"plans, submitted or approved by the Minister, shall be subject to the joint approval of the Board and Contractor."* If under that clause, the Board and contractor should not agree, or even if they did agree, in overruling the Minister (who, by the way, appoints the Board), what then? It would seem that even greater confusion of authority is here evident than existed for the bridge which collapsed. Directions may be variously issued under those specifications by the Board, by a Chief Engineer, who may or may not be a member of that Board, and by the Minister of Railways and Canals, for whom among other things is reserved the determination, presumably as befitting his rank, of the last two coats of paint (§ 295). Engineers who draft such specifications, or countenance them, make the engineering profession ridiculous, and lay it open to reproach, not infrequently heard in the press and from public men, that they lack in executive and administrative ability. It would be painful in this connection to contrast the engineering conduct of this work with the very able management of the construction of the Forth Bridge by its engineers, who upheld the best traditions of the profession and richly deserved the honors bestowed upon them.

Of other provisions of the specifications it could have been foreseen that they would greatly increase the cost of the work, without any corresponding benefit. Such was the provision of a deposit of $500,000 *in cash* with any tender, as a guarantee that the bidder will accept the contract if awarded to him. A deposit of a certified check with tender on public work is usual and necessary to exclude irresponsible bidders, but that the deposit with the tender should be so large and *in cash*, withdrawn from bankable funds, is an onerous and unwise provision, because it has the effect of reducing the number of responsible bidders and greatly increasing the cost of the work.

So also is the provision of an additional deposit *in cash* of 10% of the contract, with only 3% annual interest on it. A large bond for large work is justifiable and should have been provided, but to insist that the security be also *in cash*, the two together exceeding the capital of some large banks, must result in another needless increase of cost. Judging from the ex-

ceedingly high unit-prices in the tenders, there is no doubt that the cost was increased many hundred-thousand dollars for a hypothetical surety. For if the bridge should fall down again, the cash deposits would be entirely insufficient to pay for the loss and damage.

Notwithstanding the unfair conditions under which the competitive plans were invited, several plans were submitted with tenders from Canadian, English, American and German firms, such is the keen rivalry for large contracts.

It was recognized that the specifications were not suited for a long-span bridge and would produce an unnecessarily heavy and costly structure. In that connection a comparison of steel weights in the Forth Bridge and the Quebec Bridge may prove interesting.

Comparative Economy of Forth Design and Quebec Design.

The Forth Bridge, being the nearest in length of span, is chosen for judging approximately the weights of steel for the cantilever spans. It was designed for the exceptionally high wind pressure of 56 lbs. per sq. ft., but with only half that pressure upon the round compression members. The live-load on two tracks is 4,480 lbs. (or round 4,500 lbs.) per lin. ft.

Only general plans with a few details, but no strain sheets, have been published of that bridge, but its stability is attested by an official loading test and the observed deflections, and by the fact that all kinds of trains (freight and passenger) pass and meet on it without restriction of speed, often at 60 miles per hour, with insignificant vibration. The writer can state this from personal observation, having timed, watch in hand, trains from one stone portal to the other, just a mile apart, in one minute.

The large spans are 1,710 ft.; the whole cantilever structure is 5,330 ft. long and contains 114,150,000 lbs. of steel, or an average of 21,400 lbs. per lineal foot of bridge (32,000 near towers and 7,000 at center of suspended spans). The original estimates were for only about 90,000,000 lbs. of steel, but these had to be increased when the Board of Trade insisted upon provision for 56 lbs. wind pressure upon flat surfaces, nearly double the first-assumed wind pressures. Hard steel (76 to 83,000) was used for the compression members, and a lower steel (67 to 74,000) for the riveted tension members. The unit-stresses in trusses are in general one-fourth of the ultimate strength for tension or compression; the mean unit-stress may be taken at ± 16,500 lbs. For members with reversional stresses, as in the suspended trusses, the unit-stresses are as low as 7,500 lbs. But as the range of unit-stresses from highest to lowest is practically in the same proportion for all cases herein compared, the lowest unit-stress need not be specially considered.

The Phoenix Quebec span was 90 ft. longer than the Forth.

To adapt the 1,710-ft. span to the 1,800-ft. span, we need only consider that the weight in the trusses and wind bracing grows approximately as the square of the span, while the weight of floor, railways, etc., grows directly as the span, from which it is found that the 1,800-ft. span would require about 2,100 lbs. more steel per lineal foot, or 23,500 in place of 21,400, with the height increased from 336 ft. to 350 ft. at the towers, but other things being equal. Of this amount 16,500 lbs. would be the proportion of steel in the trusses, towers and anchorages, sustaining the vertical forces from the entire dead-load and live-loads; 5,500 lbs. of steel, divided between trusses and bracing, to resist the lateral forces from wind pressure; and 1,500 lbs. of steel in the floor system and buckle-plate floor cover. These weights, and the Forth Bridge thus adapted to the 1,800-ft. span, are hereafter referred to as the FORTH DESIGN.

The PHOENIX BRIDGE which collapsed was intended for a live-load of 8,000 lbs. per lineal ft. of bridge (78% greater than in the Forth Bridge) and for a hypothetical live-load of 12,000 lbs. under certain conditions, which may be ignored. It was 2,800 ft. long between anchor piers and contained 74,000,000 lbs., or an average of 26,400 lbs. of steel per lineal foot. Of this amount 16,500 lbs. is the proportion for the vertical forces, carrying the entire dead and live-load; 6,300 lbs. in trusses and bracing were required for lateral forces from wind pressure; and 3,600 lbs. were in the floor system. The steel (60,000 to 70,000) was the usual quality in American bridges.

The BOARD'S DESIGN was for a live-load of 11,840 lbs. (or round 12,000) per lineal foot of bridge (50% greater than in the Phoenix Bridge, and 167% greater than in the Forth Bridge) and contained, in a length of 2,934 ft., 147,500,000 lbs., or an average of 50,300 lbs. of steel per lineal foot. There was also an alternative cantilever design by the Board, with the same middle span with shorter anchor arms, length over all about 2,600 ft., of a total weight of 133,000,000 lbs. without approaches. Although the total steel is less, the average per lineal foot is nearly the same (51,000 lbs.) and does not affect the reasoning further on. The amount of 36,300 lbs. may be taken in either design as the proportion of steel in the trusses, towers and anchorages for the vertical forces carrying the entire dead and live-load; 7,000 lbs. in the trusses and bracing to resist wind pressure; and 7,000 lbs. in the floor system, railings, etc.

The figures are tabulated for easier comparison (Table I.).

TABLE I.—COMPARISON OF THREE TYPES OF CANTILEVER BRIDGE FOR QUEBEC; AVERAGE WEIGHT OF STEEL AND LOADS.

(Pounds per lineal foot.)

	Adapted Forth Design.	Phoenix Bridge.	Board's Design.
For vertical forces:			
In trusses	16,500	16,500	36,300
In floor and railings.	1,500	3,600	7,000
For lateral forces, wind	5,500	6,300	7,000
Total steel per lin. ft. of bridge	23,500	26,400	50,300
Track, roadways, wires, etc.	1,000	3,500	6,500
Snow	1,000	1,500	1,500
Total dead load	25,500	31,400	58,300
Live load	4,500	8,000	12,000
Total, dead plus live	30,000	39,400	70,300
Height of towers	350 ft.	325 ft.	290 ft.
Width	126 ft. to 33 ft.	67 ft.	88 ft.

The differences in length of anchor arms and suspended trusses in these three designs (or in fact the absence of any suspended trusses, as in the Blackwell's Island Bridge) with the same length of channel span, affect only the distribution of the steel in the trusses, but do not essentially affect in this case the average weight of steel per lineal foot, which can be taken for comparison as an index of economy for the entire length of cantilever structure. Differences in height and form of trusses, in the web system, and in the unit-stresses, have a much larger effect upon the average weights of steel per lineal foot, and therefore upon the total amount of steel.

Comparison of the Quebec Cantilever Designs.

FORTH DESIGN.—Let us now assume the Forth design carrying a load of 8,000 lbs. (instead of 4,500) on two tracks, as in the Phoenix Bridge. How much would the unit-stresses in the trusses be increased for the vertical loads?

The greater live-load of 8,000 would first require 500 lbs. more steel in the floor system, therefore dead-load = 26,000. The total Dead + Live would be: 26,000 + 8,000 = 34,000 lbs. The new mean unit-stress (u) in the trusses may be found from the old average unit-stress 16,500 in relation to $D + L$ thus:

$$\frac{16{,}500}{30{,}000} = \frac{u}{34{,}000}, \quad u = 18{,}700 \text{ lbs. per sq. in.,}$$

which is 13.3% greater, for a live-load 78% greater.

The average stress of 18,700 for both tension and compression would still be within safe limits for the high steel in the trusses of the Forth Design, although the increase of unit-stress would, of course, be somewhat larger in the suspended trusses than in the cantilevers or anchor arms.

PHOENIX BRIDGE.—With slightly less height of trusses at towers than the Forth Design (325 ft.), the Phoenix Bridge was [illegible] 67 ft. wide against the Forth Design 120 ft. at towers and 33 ft. at middle of span. It required more steel for the wind forces. (See Table I.)

The loading of two railway tracks (E 40), two roadways and two trolley lines required more steel in the floor and carried larger floor weights than in the Forth Design, which has only two railway tracks and two sidewalks. (See Table I.). The snow load also was larger.

The Phoenix design had the same amount of steel (16,500) for carrying 39,400 lbs. (the entire D + L) as the Forth Design for carrying 30,000 with mean unit-stress of 16,500. The Phoenix unit-stress u_1 for vertical loads is therefore higher:

$$\frac{16{,}500}{30{,}000} = \frac{u_1}{39{,}400}, \quad u_1 = 21{,}700 \text{ lbs. per sq. in.}$$

For a live-load of 12,000 the unit-stress would be 24,000.

These unit-stresses agree closely with the average actual stresses found in the trusses of the Phoenix Bridge. It was discovered after the collapse that the compression unit-stresses in the bottom chord of the completed bridge would have varied, for the live-load of 12,000, from 12,900 to max. 30,200, with similar great variations in other parts of the bridge—the result of errors in the computations of dead-load. The stress of 24,000 average is too high for low steel but would be amply safe for nickel-steel, which is 50% stronger. The conclusion is justified that if:

(a) the trusses in the collapsed bridge had been of nickel-steel, and correctly dimensioned,

(b) the compression members of a rational form, and

(c) the bridge of somewhat greater width,

it would have been entirely safe with its weight of metal (74,000,000), not only for the 8,000 but for the intended 12,000 lbs. emergency live-load.

BOARD'S DESIGN.—In the Board's Design the trusses were almost entirely of nickel-steel, the floor and bracing of carbon steel. The middle span is 1,758 ft., that is 42 ft. less than in the Phoenix Bridge, but this difference does not sensibly affect the conclusions below and in any case would affect them only on the safe side.

The greater width of the bridge required longer wind struts, and the larger surfaces received larger wind pressures, so that including the proportion of steel for wind in the trusses, the total for wind is the before-mentioned 7,000 lbs. steel per lineal foot. The floor was heavier by reason of greater live-load, greater width, and heavier track and road details; the floor girders, hand railings and other details required 7,000 lbs. steel, as before given. The weight of tracks and roadways, paving, etc., was 6,500 lbs.

Nickel-steel can safely be used in trusses of long spans with unit-stress of 30,000 lbs. (reduced for compression), because the maximum stresses occur without shock or impact, if they ever do occur. But assuming the average unit-stresses to be kept at about one-fourth of the ultimate strength as in the Forth Bridge, then 22,000 would be a fair mean value for nickel-steel. We can deduce from the Forth Design the average steel, x lbs. per lin. ft., required to carry the total Dead + Live with 22,000 unit-stress as follows:

If in the Forth Design a unit-stress of 16,500 carries the entire dead and live-load of 30,000, how much D + L will a unit-stress of 22,000 carry?

$$\frac{16{,}500}{30{,}000} = \frac{22{,}000}{D+L}; \quad D + L = 40{,}000$$

If in the Forth Design 16,500 lbs. steel per lin. ft. are required to carry 40,000 with unit-stress of 22,000, how many pounds steel are required to carry the entire dead and live-load, which is:

$x + (7{,}000 + 7{,}000 + 6{,}500 + 1{,}500 + 12{,}000) = x + 34{,}000.$

See the above table, 3rd col., for these weights. The proportion is:

$$\frac{16{,}500}{40{,}000} = \frac{x}{x+34{,}000}; \quad x = 24{,}000.$$

The steel per lineal foot is, therefore:
Nickel-steel 24,000 for vertical loads,
Carbon steel 14,000 for floor and wind pressure (see table).

Total 38,000 per lin. ft. of bridge.

For a bridge 2,934 ft. long, the total would be 111,500,000 lbs. steel.

The Board's Design No. 1 contained
35,700 nickel
14,600 carbon

50,300 lbs.,

or a total of 147,500,000 lbs. in the cantilever portion 2,934 ft. long.

The excess of 36,000,000 lbs., all nickel-steel in the trusses, may be ascribed to the low height at towers (290 ft.), to the straight chords, to the heavy steep-angled web-system, and to low unit-stresses in many parts of the trusses, all of them unnecessary features.

CONTRACTOR'S DESIGN.—Assuming now a reduction of live-load from 12,000 to 10,000 lbs., and a lightening of the dead-load by leaving off the roadways and trolley lines, as in the plan made by the contractor and accepted by the Government and to be actually executed:

This would reduce the steel in the floor from 7,000 to 4,800 lbs. and the weight of flooring from 6,500 to 1,500 lbs. Less steel is required for the vertical loads, and its weight x can be found as follows:

$$4,800 + 7,000 + 1,500 + 1,500 + 10,000 = 24,800$$

Live-load plus Dead-load except trusses.

$$\frac{16,500}{40,000} = \frac{x}{x + 24,800}, \text{ or}$$

$x = 17,400$ lbs. for vertical load.

17,400 nickel
11,800 carbon

29,200 lbs. per lin. ft.

Then the total is 85,700,000 lbs. for the cantilever part (2,934 ft. long).

The above figures are sufficiently close indices for orientation so that the engineer may judge in the general layout of the cantilever design what his total weights may work out to, and where economy can be applied.

Excellence of the Forth Bridge Design.

The more the Forth Bridge design is studied, the more evident it appears that the engineers of that structure used with masterly skill every device that would promote economy, stability and reserve of strength. They had no precedents to go by, and had to solve the problems on original studies. The enormous difficulties arising from the extremely large riveted connections, and in providing for them the necessary large contact surfaces, all of which enhance weight, were ingeniously met. In this respect the American pin connections offer the great advantage of simplicity, cheaper fabrication and easier erection, which were not available to the English engineers.

Its architectural appearance is imposing, but not sightly. A different treatment of the towers and a slight bend in the top chord of the high trusses would have esthetically enhanced the character of the cantilever type. But this would have produced greater complexity in the angles and conditions of web members, lying in warped surfaces, which may have been the reason for not doing it.

The writer did not, at one time, favor the insertion of the stiff diagonal members (subject to tension and compression) in the side towers, regarding them as redundant members, which made that part of the system statically indeterminate. That was before the completion of the bridge. But the official tests later on showed remarkably small deflections, maximum only 5 ins. for the Queensferry cantilever ends, 1/4,100 of the span, and this result may be due in large part to the stiffening effect of those diagonals, which also help to reduce the secondary stresses in the trusses. A comparison with the double-track railway bridge of 470 ft. span over the Niagara River will in part confirm this view. The trusses here have no diagonals in the towers. The bridge was tested in 1883 and showed a maximum deflection of 7¾ ins., or 1/730 of the span.

It appears that the Forth Bridge, although designed for a live-load of only 4,500 lbs. per lin. ft., can safely carry much heavier train loads, as indicated above.

Possibilities of the Cantilever for Quebec.

If the competitive designers for the Quebec Bridge could have been at liberty

First, to use in the trusses unit-stresses averaging one-fourth of the ultimate strength of steel as in the Forth Bridge, which are more than ample;

Second, to choose greater height in trusses as in the Forth Bridge, thus reducing the chord stresses;

Third, to use curved bottom chords, thus carrying a large part of the web loads directly to the piers and reducing the web stresses (the bottom chords in the Phoenix Design are too sharply curved and are liable to produce reversible web stresses, which must be avoided in long members); and

Fourth, to use double or multiple-system webs, thus with small ambiguity obtaining the great advantage in a heavy bridge of diffusing the web stresses and reducing the column lengths and the bulkiness of connections;

Then the competition would have proven that a cantilever bridge with the same large margin of strength as the Forth Bridge could have been produced for a live-load of 12,000 lbs. (retaining the heavy floor-system of the Board's Design) with about 112,000,000 lbs. of steel, as indicated above. The saving over the official design, which contained 147,500,000 lbs. in the cantilever portion, would have been (at the lowest unit-prices bid) about $2,700,000.

The comparative outline drawings of the Forth Bridge and the three Quebec designs mentioned in the preceding, Fig. 2, may be referred to in this entire discussion.

But every feature which would tend towards economy was inhibited by the specifications, without any apparently good reason. The height of trusses was arbitrarily limited to 290 ft. The chords of the cantilever and anchor arms had to be straight; but the top chord of the suspended span, curiously enough, could be curved.

The trusses of the official design contained enough steel to carry, in better designed trusses, with a large margin of safety, the floor and train loads of four heavy railroad tracks, besides the wagon roads and trolleys; while the floor was dimensioned for only just two railroad tracks, two roadways and two trolley lines. It was not in any respect a well balanced design.

The Accepted Plan.

About 24 tenders and eight or nine competitive plans were submitted by four bidders. The only variations in the cantilever bridge of the Board's Design offered by bidders related to erection, web details, and length of anchor arms. The tenders on the Board's Design varied from $11,000,000 to the extravagant price of $16,000,000, and from 7.6 cts. to 11 cts. a pound for all steel (carbon and nickel).

Among the competitive plans there were indeed several (all from one firm) which were much lighter and cheaper than the Board's Design, *but these were, every one, in contravention of the official specifications.* Dire consequences were apprehended by the tenderers, the least of which was the throwing out of their plans if they did not comply in every respect with the Board's specifications. One firm, understanding probably better than the others the home-atmosphere, dared to ignore the rules of the game, and in that way it happened that cheaper designs were submitted. One design had only 96,000,000 lbs. of steel in it, including approaches, and cost $9,000,000; it was just the plan chosen and accepted by the Canadian Government.

The Government's Attitude.

The action of the Government in this respect was not fair to the other competitors, who had acted honestly and in their designs had strictly adhered to the conditions laid down. There is no doubt whatever that, had they taken similar liberties with the specifications, the nine-million-dollar design would not have been the cheapest.

But what was an ill-advised, perplexed Minister of Railways and Canals to do?

The Canadian Government had already expended (or obligated itself for) over $7,000,000, including the cost of the collapsed structure, engineering and contracts for new piers, and had lost three years' time in commencing the new bridge, with the interest account running on. From the fact that the very costly Board's Design was not adopted by the Canadian Government it can hardly be claimed that in the end it valued highly the ability and the expensive services of its own technical advisers.

The responsible Minister had to find out in that way, almost by accident, that a strong and serviceable bridge structure could be built for a sum much below the cost of that official design. One can understand how under these circumstances he may have had the desire to lose no more time, and that probably from motives of expediency he adopted, although in violation of good faith to all the other tenderers, the lightest and cheapest design (but not the cheapest in unit-price) submitted to him.

That the rules of ethics which govern honorable men in their private affairs may thus be ignored by officials in public affairs, seems to be viewed by the public in this age not as the immorality which it is, but as a matter of indifference. So the "injustice" had to be accepted with complacency by those directly concerned—there was no help for it.

The public interest would have been better protected if all the plans had been rejected and new plans and tenders invited. With the preparation which all the bidders had, new plans and bids could have been submitted by them in two months' time. But to order and do these things would have required some competent head, which did not exist.

Nor does any really responsible technical head seem to exist now. Since the conclusion of the contract there have been other changes in the personnel of the Board, only one of the original members remaining. There are good reasons for the belief that quite different and better results would have been produced by the present Board; but it is too late. The contract is made and the hands of the Board are now tied. Under the contract the entire responsibility for design, execution, etc., had to be assumed by the contractor, as above mentioned, so that the present Board, it appears, has no discretion, no power and no responsibility, except that of seeing that the work is executed as per contract.

No detailed information about the adopted design has been published. The proportions of nickel and carbon steel have not been stated. Those who have studied the Quebec problem will at once concede that a good cantilever bridge and its approaches can be built within 96,000,000 lbs. and within the contract price of $9,000,000. But it is also a fact that within the same weight and price the bridge could have been made sufficient to carry two heavy railroad tracks, two wagon roads and trolley lines, since the live-load of 10,000 lbs. per lin. ft. is ample for these on an 1,800-ft. span; and this fact the Canadian Government could ascertain for itself, if it chose seriously to do so. If, as reported, the adopted design does not provide for wagon roads and trolley lines, then the choice is a stupid blunder, not by any means excusable by an apparent saving in cost over the other plans submitted, which had complied with wasteful specifications.

It is also stated that riveted connections are to be used throughout and that the tension members are to consist of nickel-steel shapes with riveted splices in place of the well-tested forged nickel-steel eyebars, so much lighter in useful weight. If this be the fact, it would be a retrogression in bridge construction for which no good reason can possibly be furnished. In that respect, at least, the Board's Design was much better.

As already mentioned, it was a distinct loss to the Government that the special knowledge and experience gained by the able engineers of the

Royal Commission, which had investigated the collapse of the first structure, was not availed of in the plans for the new structure. They were particularly well qualified and cautioned by their investigations to draft specifications for and to sit in impartial judgment on new designs, which should have complied with the high standards which can be set for such work. Several million dollars and at least two years' time would have been saved in that way.

The desire of the Canadian Government to have the bridge built in Canadian shops and with Canadian steel as far as practicable was perfectly legitimate, and should have been frankly stated in the invitation to bidders, instead of veiling its intentions by the pretense of an international competition, which was a farce and which put English, German and American bridge firms to large and unnecessary expense.

The Esthetic Phase of the Quebec Bridge Problem.

The esthetic considerations which present-day civilization has a right to expect in a work of this magnitude and importance were entirely neglected. Not a word on that feature was contained in the specifications; not the slightest effort was made in that regard. There are several cantilever structures, in this country and abroad, which prove that they can be made architecturally sightly.

The bridge which collapsed had some grace of outline; so has also the Forth Bridge, so much derided for its bulky appearance. But none can be claimed for the new cantilever designs for the Quebec Bridge, which are ugliness itself. It would seem that as in no other monumental work, benighted amateurishness found true expression (we may believe, quite involuntarily), not only in the coarse outlines of the structure, but even in such small features as the short approaches consisting of little, miserably weak-appearing girders on the slopes between the abutments and the anchor piers, instead of solid concrete masonry arches, which cost hardly more at present cement prices.

As is well known, the cantilever bridge is one of the oldest types. Some ancient examples still exist, built by savages of tree trunks and bamboo sticks, anchored down with boulders. Made almost without tools and with scanty resources, the vernacular architecture of these crude structures, set into a wild landscape, has a certain charm of its own which is a delight to the lover of simple comeliness and should be a lesson to the educated engineer.

To give a pleasing form to its creations seems to be an instinct of the human race as far back as history can trace it. The higher the culture, the more refined that instinct, in all races and in all ages, as proven by thousands of structures for thousands of years. This fact makes architecture an accepted standard and measure of civilization. It remained for the modern metal bridge engineer to change that notion and to create in conspicuous locations unsightly structures and even to feel proud of them. Every large bridge destined to last many centuries should be designed on pleasing lines. This need not add anything to its cost but requires a little more work and study. Posterity, more enlightened in science and art, may well ask whether the wits of the designers of the Quebec Bridge were all used up by details and strain sheets so that none were left for artistic form and character.

As long as engineers as a class are indifferent in this regard, or satisfied to be mere utilitarians (and sometimes mere tyro utilitarians at that, ranking in this respect below their unlettered forbears and in our day not above the mere mechanic), so long will they experience and merit the low esteem which cultivated taste and minds accord to them in esthetic matters.

Here in the case of the Quebec Bridge, destined to last centuries, was an unhampered opportunity for engineers to prove, if they could, that an esthetically pleasing form can be given to a large bridge, whatever its type. The result is disappointing and lamentable; it will not represent, as it should, the good work that can be done in the twentieth century.

(Part II. will appear in a later issue.)

The Repair of a 9,500-ft. Leaky Steel Plate Pipe Line at Boulder, Colo., by Oxy-Acetylene Welding.

By LOUIS ELLIOTT.*

The Boulder pressure line of the Central Colorado Power Co. is a steel-plate riveted pipe about 9,500 ft. long on the slope, and varying in inside diameter from 44 ins. to 56 ins. The static head on this pipe is approximately 1,830 ft. Beginning with the first field test of the pipe, trouble was experienced from leakage. After various attempts to stop the leaks by calking and other methods, success was attained by welding with an oxy-acetylene torch.

The light portion of the pipe is lap riveted at both longitudinal and girth seams. The heavy portion of the pipe, which has a slope length of 4,400 ft. and weighs about 3,000,000 lbs., is butt-welded with a longitudinal-joint efficiency of about 80%. The slope on which the pipe is laid varies from 5° up to about 45°, a good part of the butt-strap pipe laying on slopes of 25° to 30° with the horizontal. The line was laid in a trench sufficiently deep to carry the top of the pipe about 3 ft. from the original surface, the foundation being either solid or disintegrated rock. Concrete saddles and anchorages were placed from 100 to 300 ft. apart where the foundation was good and closer where poor. Near the lower end the pipe passes through a tunnel about 300 ft. in length; through this tunnel the pipe is supported by brick piers placed under every other field section, or about 42 ft. apart.

The leakage was found to be by far the most serious at the field joints of the butt-riveted pipe. A sketch showing the make-up of these joints is given in Fig. 1. The outside longitudinal strap is double riveted, the inside triple riveted, and the girth single. The plate in the butted pipe varies from ½-in. to 1¾ ins. in thickness. At field and shop joints in the butt-riveted pipe the girth strap is interrupted at the longitudinal strap and the ends of the former tucked under the latter. (Section A-B, Fig. 1.) The inside longitudinal butt strap is interrupted at the center of the joint, or at the parting of the main plate of the pipe. The outside strap is carried across the joint to a position flush with the edge of the girth-seam strap, and at this point the longitudinal strap on one section is tucked under that of the other. (Section C-D, Fig. 1.)

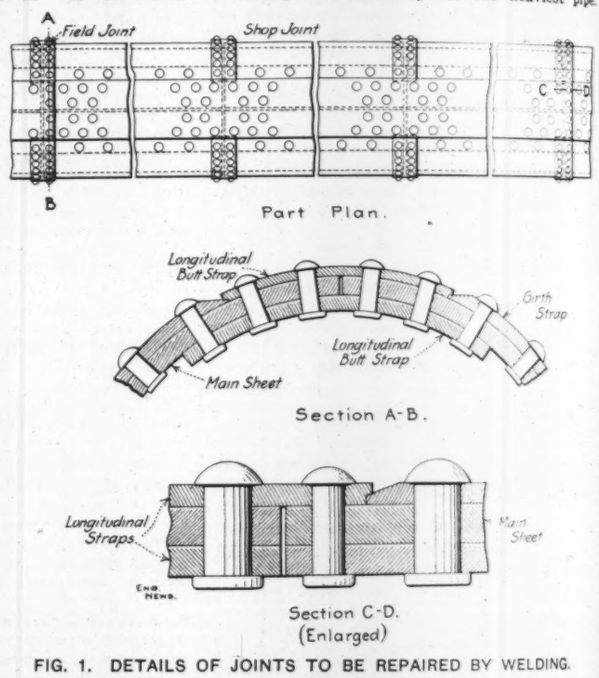


FIG. 1. DETAILS OF JOINTS TO BE REPAIRED BY WELDING.

(The ends of the outer longitudinal butt straps were welded together at the field joints, and were also welded to the girth straps at these points.)

The character of calking employed to make the pipe tight was usually of the type known as "split" calking, and, in consequence, at many locations calking finally became entirely ineffective. It may be seen, moreover, from the design of the field joint that at the positions where the tuck occurs it is impossible to get at the edge of the metal to calk it properly, and this has been the chief seat of the trouble. From most of these tucked joints, a sheet of spray would emerge during the test, as shown in Fig. 2, and leakage was present at nearly every field joint and at some shop joints. Repeated attempts were made by calking inside and outside the pipe to make these field joints tight, and often this calking would prove effective for a short time. After a short time, however, the leak would break out afresh.

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Method of Welding.

It came to the point that some method of welding seemed the only alternative to replacing the pipe. Thermit was tried in a few cases, but it was found extremely difficult to make and secure the mold so that it would contain the molten metal during the process of combustion, and at the same time great danger was run of permanent injury to the pipe.

Next tried was the system employing high-pressure oxygen and acetylene, using apparatus made by the Davis-Bournonville Co., of New York,* and this finally proved so satisfactory that the entire length of butt-riveted pipe was repaired by this means. At each of the field joints and at some few of the shop joints, the leaking seams where the butt straps come together were welded by the oxy-acetylene torch. The weld was made in the outside butt straps only, not in the main sheet of the pipe itself. The size of torch known as No. 11 was used for most of the work, the No. 12 size being called upon occasionally for the heaviest pipe.

The first trials were exceedingly discouraging, as the contraction of the pipe upon cooling usually operated to form cracks in the weld. Improvements in the details of the method were gradually introduced until complete success was attained.

It was found that the special grade of Norway iron furnished for use as a "soldering stick" in this process was by far the most suitable for the added metal. It was also found necessary to pein the weld before it cooled in order to spread the metal and avoid cracks. Any such filler as copper previously calked into the joint to make it tight would prevent a sound weld, and such foreign material had to be cut or burned out before the weld could be made a success. It was found necessary, moreover, to cut out the joint and bevel back the plates where they were to be welded together, so that new metal could be added and the weld made to the full thickness of the plate; before this was done the added metal merely formed a bridge across the junction of the plates, the welding heat not having penetrated to the bottom of the seam.

One of the chief problems was whether to weld the outside butt straps solidly to the main plate of the pipe or to allow them to be free providing a substantial calking edge. It was de-

*For description of this apparatus see Eng. News, Nov. 19, 1908, p. 547.

termined after several trials that it was necessary for the straps to creep slightly on the plate during expansion and contraction from temperature changes and that securing the straps solidly to the plate caused cracks in the weld. This applied especially to the corners between the longitudinal and girth straps.

One of the chief improvements effected, however, was the reheating of the pipe above and below the weld just following its completion. This heating tended to put the weld temporarily under compression and distributed the cooling stresses over a considerable length of the longitudinal butt strap, which now forms a seamless length of steel.

Fig. 2. During Pressure Test, Showing Leakage Between Ends of Longitudinal Butt Straps.

Fig. 3. Completed Joint: Note the Fillet Welded In At Corners of Longitudinal and Girth Straps.

FIGS. 2 AND 3. A TYPICAL LEAKY JOINT BEFORE AND AFTER WELDING.

The first welds were made carrying the surface of the added metal not far above the original surface of the butt straps, but as the work proceeded it was found advisable to increase the thickness of the weld in order to prevent the occurrence of cracks. The final practice was to make the weld to a template and to add reinforcement until the metal stood above the original surface by a height of about 40% of the thickness of the straps; the added metal also extended several inches along the butt straps in both directions from the center line of weld, enclosing a row of rivets on each side. At the corners between the girth and longitudinal straps considerable metal was added, first from a "soldering stick" by means of the oxy-acetylene flame but finally by cutting out (by a "cutting" torch) a triangular piece of steel of the same thickness as the butt straps and welding this piece to both the longitudinal and girth straps.

The cutting out of the joints and the beveling back of the plates was at first done entirely by hand chisel and double jack, but later a 5-in. stroke compressed-air chipping hammer was used. This air hammer was also used in trimming off the weld after completion prior to the calking, as well as in the final calking itself. The edges of the longitudinal butt straps were beveled off for a foot or more each side of the weld in order to facilitate the final calking.

Making Tight the Welded Joints.

As spaces of varying thickness occurred between the butt straps and the main plate of the pipe, it was thought advisable to fill in such spaces with some viscous material which would remain permanently in that condition and assist in making the pipe tight, this work to be done after the welding and before trimming or calking. The first material used was red lead in linseed oil, but it was found upon testing the pipe under pressure that the oil in the red lead was forced out at the joints. Glycerine and litharge were also tried but were not found to be very suitable.

It was finally decided that some bituminous compound would best answer the purpose and two grades of elaterite, both manufactured by the Western Elaterite Roofing Co., were used. The first was a hard compound which had practically no oil in its composition, and this had to be forced into the pipe while the weld was still hot; it was found impracticable to fill the joints as was required. The next grade used was what is termed roof repair cement, which is elaterite mixed with a small proportion of oil to give it a stiff putty-like consistency. By heating this material, and also by heating the pipe along the channel which it was desired the elaterite should take, the voids could be filled in the most satisfactory manner. The compound could often be made to travel for several feet between the plates of the pipe, and would emerge from under the loose edges of the weld before calking and also around the rivets.

A special plunger pump, 15/16 × 12 ins. inside, was used for this purpose, the pressure being applied by means of a thread on the plunger. The theoretical pressure was several thousand pounds to the square inch. The pump was connected to drilled and tapped holes in the outside butt strap adjacent to a joint, by means of a ½-in. extra heavy nipple. It was found advisable to drill, tap and plug holes along the line of the longitudinal seam of the pipe so that the compound could not be forced along this seam and down into the pipe. Before being plugged, these holes were tamped partly full of sheet lead and the plug, which took the form of a ⅞-in. cap screw, was made long enough to pass merely through the butt strap; this allowed the strap to slide on the main plate without shearing or crushing the plug. Four of these cap-screw plugs, and the ½-in. nipple through which the filler was pumped to the space between butt strap and pipe, can be seen in the completed joint shown in Fig. 3.

Fig. 4. Welding a Joint in the Open; Showing the Plank Shelter Walls to Protect the Workmen.

Before the joint was called complete, it was trimmed and the edges beveled and calked very carefully, usually by the air hammer; the system known as "fuller" calking was employed. This was carried from 12 ins. to 15 ins. down the sides of all the butt straps and around all the rivets affected by the welding.

Oxygen and Acetylene Supply.

Oxygen was manufactured at the site by the usual method of heating potassium chlorate and manganese dioxide, the proportion being about 9 to 1. The released oxygen was passed through two barrels of water and one containing a solution of caustic soda into a small gas holder, from which it was taken by an oxygen compressor and stored in small steel tanks at a pressure of about 300 lbs. per sq. in. These tanks were transported to the location of the welding and a continuous supply kept on hand. It was found necessary, however, in order to maintain this supply for one shift of welding that the oxygen plant be kept in operation for 20 hours of the day.

The acetylene was also manufactured on the ground from calcium carbide by means of two 50-lb. acetylene generators. It was found possible by the use of receivers inserted in the line to pipe this acetylene several hundred feet from the generators to the location of the welding. The pressure maintained at the generators was about 17 lbs. per sq. in. and the pressure obtained at the torches was only slightly less. In order to furnish a continuous supply of gas to the welders the charging and operation of the two generators was alternated. Water was carried in barrels, although freezing caused considerable trouble. As the section of pipe welded was 4,400 ft. in length it was necessary to move the acetylene apparatus several times during the course of the work. This was accomplished, however, with very little interruption, as tanks of acetylene were always kept on hand for such emergency work.

During the work in the tunnel (Fig. 5) it was found most convenient to maintain an oxygen line extending the entire length of the tunnel. The pressure in this line was held at about 40 lbs. per sq. in., and two tanks of oxygen were usually kept connected to this pipe by means of a manifold and through a reducing valve; as the pressure in these tanks fell to 40 lbs., fresh tanks connected to the manifold were opened up. In this way pressure at the torches was kept practically constant throughout the working day, permitting no delay in the welding from this cause. In all except this tunnel work, it was necessary to change the oxygen tanks feeding the torches every half to three-quarters of an hour, which caused a delay of about one minute for each change.

Fig. 5. Making One of the Welds in the 300-Ft. Tunnel.

Organization of the Work.

The working force was thoroughly organized, being divided into several groups. The first group of men cut out the joints; the second group consisted of expert welders doing the actual welding; the third drilled and tapped the holes into which the compound was forced; the fourth did the "doping," and the fifth consisted of boiler makers for the trimming and calking.

As the use of the pressure line was required at the earliest possible date it was necessary to do everything possible to push the work. The speed depended primarily on the progress of the welding proper, and accordingly everything was

subordinated to this department of the work. Throughout a large portion of the time six expert welders were kept busy, there being two to a gang, as it is practically impossible for one man to weld continuously on account of the intense heat. The two men in a gang would change about and in that way keep the torch in operation practically the entire day. The time consumed in making one weld varied according to the thickness of the plate from about 20 hours a joint in the exceedingly heavy plate at the bottom of the pipe to about three hours per weld in the ½-in. plate at the top.

The field joints after excavation were boxed in with 2-in. rough lumber, as shown in Fig. 4, to provide a convenient and sheltered space for the work and in order to allow access to the joint after completion of the work. This single point contributed in a considerable degree to the speed with which the work was done.

An almost indispensable aid to the work was the 4-ft. gage tram served by an electric hoist, by means of which all men and material were transported from the powerhouse camp to the site of the work. The vertical lift to hoist house was about 1,000 ft.

The work was organized and carried on by Mr. E. M. Gilbert, Chief Engineer for the Central Colorado Power Co., and to his energy and resourcefulness are due in large part the rapid completion of the work and its final success. Mr. W. von Vintschger, welding expert for the Davis-Bournonville Co., initiated the actual welding, and instructed local men in the handling of the torch. The conditions under which the work was carried out were rather severe, as it was done during the months of December, 1910, to March, 1911, inclusive, with high winds, snow and low temperatures a good part of the time.

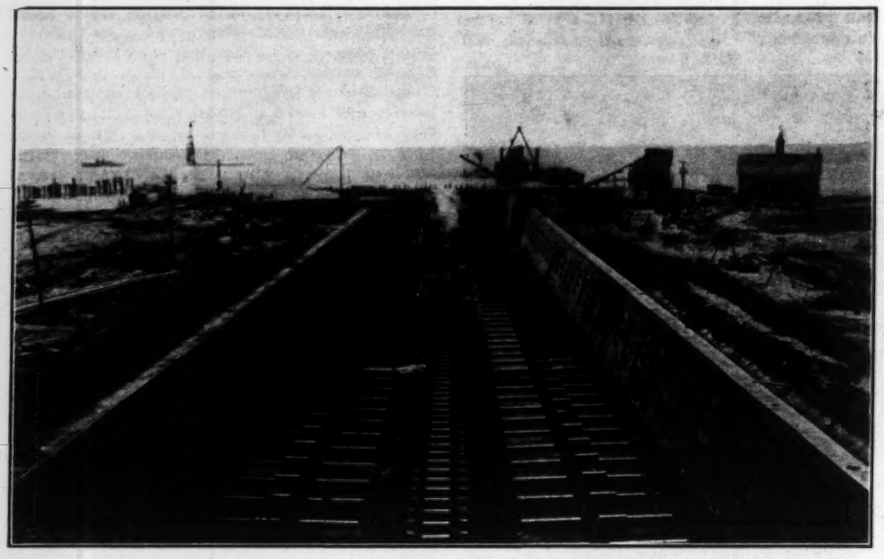

FIG. 1. CONCRETE DRY DOCK OF THE WESTERN DRY DOCK & SHIPBUILDING CO. AT PORT ARTHUR, ONT., CANADA.
A. V. Powell, M. Am. Soc. C. E., Chicago, Consulting Engineer.
Canadian Stewart Co., Montreal, Contractor.

Dry-Dock at Port Arthur, Ont., Canada.

By A. V. POWELL,* M. Am. Soc. C. E.

[For the accommodation of Canadian shipping on the Great Lakes, and particularly in view of the lack of dry-dock accommodation on Lake Superior, a large dry-dock has been built at Port Arthur, Ont., by the Western Dry-Dock & Shipbuilding Co. (which is affiliated with the American Shipbuilding Co.). This dock is capable of taking the largest vessels on the lakes, being 700 ft. long, with a clear width of 77 ft. 6 ins. at the entrance or portal, and a depth of 16 ft. of water over the sills. In connection with the dry-dock there is a complete shipbuilding plant, ships being launched sideways into the dock. The work now completed consists of the dry-dock, two shipbuilding berths, a large steel punch shop and a machine shop.

The plans and specifications were prepared by Mr. A. V. Powell, M. Am. Soc. C. E., Consulting Engineer, of Chicago, and we are indebted to him for the description of the dock which is given herewith. Fig. 1 is a view of the completed dock, but with the cofferdam still in place at the entrance. The form and dimensions are shown in Figs. 2 and 3.—Ed.]

Thunder Bay, on Lake Superior, is a body of water 16 by 26 miles in extent. It forms one of the best harbors—if not the best—on the Great Lakes. It is connected with Lake Superior by two outlets, two and four miles in width, and is protected from the winds by the palisades of Thunder Bay and Pie Island, 1,200 and 1,500 ft. high. The cities of Port Arthur and Fort William are located on the northern shore of the bay, near the western end, and except in name form a single commercial center, the only port on the Canadian side of Lake Superior. To this port the three great transcontinental railways of the Dominion bring the products of the grain fields of central western Canada, and to it also the shipping of the Great Lakes carries the manufactured commodities and fuel for the great Northwest. Ships encounter storms and meet with disasters, hence dry-docks are needed for repairs. Ships are lost, and more ships are needed to carry the increasing traffic, so shipyards are required. These needs account for the formation of the Western Dry-Dock & Shipbuilding Co., Limited, of Port Arthur, Canada.

LOCATION OF DRY-DOCK.—In order to carry out the proposed undertaking in the manner that the enterprise seemed to justify, and to provide room for extending the facilities when the growth of business were required, about 100 acres of land were needed, so located as to give not less than half a mile of dock frontage for dry-docks, shipbuilding berths, fitting-out slips, etc., and room in front for laying up ships for repair during the winter. In addition to this, an absolutely safe foundation must, if possible, be secured for the dry-dock. The site must also be as near as possible to the shipping center of the district.

With these requirements in mind, nine locations were prospected, covering a bay frontage of seven miles. At all these points borings were made, and where satisfactory foundation was found preliminary estimates of cost were prepared. Finally a report was submitted, which was adopted, fixing on the Current River site for the plant.

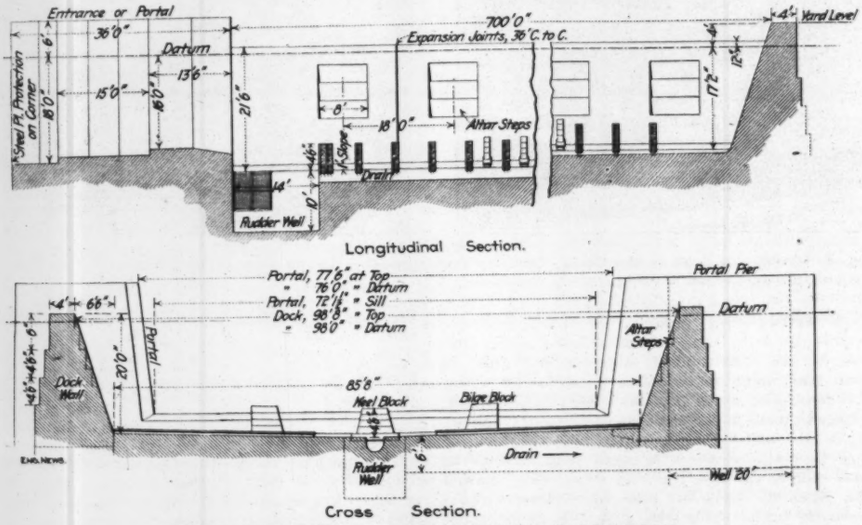

FIG. 2. SECTIONS OF THE PORT ARTHUR DRY DOCK.

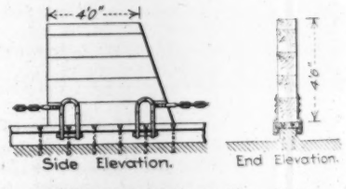

Fig. 2A. Detail of Bilge Block.

This location met all the conditions mentioned above in regard to foundation, water front, area and railway facilities, and was sufficiently near the shipping district.

Very complete borings were taken over the property before the docks were located (room having been reserved for another dock of the same size as the one constructed, and served by the same pumping plant). The place fixed upon put about two-thirds of the length of the docks outside the original shore line, the portal of the present dock being where the water was about 10 ft. deep.

FOUNDATION.—The entire dock is built on solid rock. Above this was found the hardest kind of hard-pan, with many boulders. About 90% of the material excavated was hard-pan. The remainder was shale rock.

CONCRETE.—The nature of the foundation precluded the use of timber in the construction of the dock, even had it been otherwise desirable, and concrete was adopted. A 1:3:5 mixture was used, which was run soft in the large masses,

*Consulting Engineer, 1007 Chamber of Commerce Building, Chicago.

side walls, portal piers, etc. It was dumped from cars running over the top of the forms, the drop ranging from 5 to 30 ft., and I believe resulted in a mass as nearly voidless as it is possible to get concrete. Timber was used for keel and bilge blocks, but not elsewhere.

DIMENSIONS OF DOCK.—In fixing the dimensions of the dock we were governed to a degree by past experience. The first dry dock I designed was constructed in 1891. At that time,

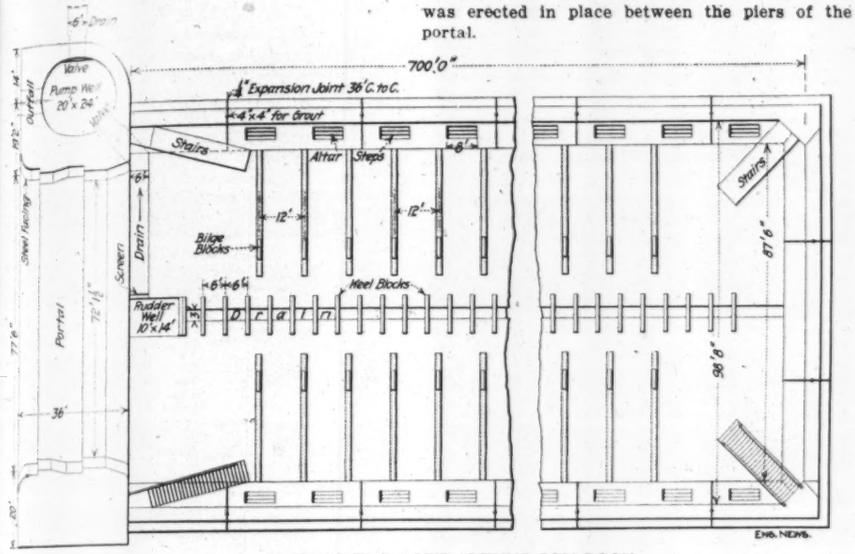

FIG. 3. PLAN OF THE PORT ARTHUR DRY DOCK.

after much thought on the part of the owners, and after getting the opinions of vessel men, we concluded that 400 ft. would dock any ship that would ever be built on the lakes. I have since lengthened that dock 150 ft., but it is now altogether too short to take the largest boats. The largest ships on the Great Lakes at the present time are 600 to 608 ft. long over all, 60 ft. beam and 32 ft. deep. They draw (aft) light about 12 ft. of water. A ship of these dimensions will have about 450 ft. of dead flat frames, that is, frames of the same dimensions as the midship section. The "dead rise" will not exceed 6 ins. and the turn of the bilge 4 ft.

In other words, the vessel is a steel box sharpened at the ends and rounded at the lower corners. As a carrier it cannot be excelled. Its model is the outgrowth of the combined experience of shipbuilders and vessel owners covering a period of 30 years, and it is fair to presume that the type will continue. It is admitted by the majority of experts that the length of the lake boat cannot be increased very much without increasing the depth of the hull, thereby increasing the weight, and consequently the draft of the ship. As the ships operating on the Lakes are now loaded to the full working depths of the channels and harbors no material benefit can be obtained from increased size without the expenditure of unknown millions for harbor improvement.

However, there is always the man who wants the biggest of everything, and he is liable to come to the front with a ship in advance of the harbor appropriations. So we made the Port Arthur dock 700 ft. long to give him a chance to come in. This length also gives a chance to dock at one time two vessels of a class largely in use. The width of the dock on the bottom was fixed at average 85 ft. This admits light, gives ample room for working, and a clear passage for material going into the dock.

The sidewalls are given a moderate amount of batter for two reasons. First; as the spaces on both sides of the dock are to be used as building berths (ships 600 ft. or more in length will be launched into this dock), the walls are kept back so that the ship's bilge will not strike when it is launched. Second; the modern ship in dry-dock rests entirely on the keel and bilge blocks and shores are unnecessary. For this reason the altars used in old dry-docks are also unnecessary. Provision is made, however, for shoring by stepping into the side walls at intervals near the top of the dock.

PORTAL AND CAISSON.—The clear width in the portal at the line of the sill is 72 ft. and the depth over the sill is 16 ft., Government datum. This gives ample depth, as loaded ships are never docked in lake dry-docks. The sill and jambs are steel. The caisson is constructed of steel, and its dimensions are given in Fig. 7. It was erected in place between the piers of the portal.

PUMPING PLANT.—The pumping plant consists of two 30-in. centrifugal pumps driven by 200 HP. d.c. vertical direct-connected motors. There is also an 8-in. centrifugal motor-driven pump for drainage. The pump well is located in the west pier of the portal and is provided with openings and valves to connect with dock No. 2 when that becomes necessary. Current for the motors driving the pumps and also the machinery of the shipyard is taken from the Current River hydro-electric plant, owned by the city of Port Arthur and located alongside the dry-dock property.

[Supplementing Mr. Powell's description of the dock and its equipment we give the following particulars of the construction work.—Ed.]

Construction Methods and Plant.

The contract for the construction of the dry-dock was let to the Canadian Stewart Co., of Montreal, and the work was carried out under the direction of Mr. Wm. R. Sinks, Manager, and Mr. R. H. Folwell, Engineer, of this company. Construction was commenced in April and completed in November, 1910. We are indebted to the company for particulars as to the construction methods and plant, from which the following description is prepared. The dock is constructed of concrete and steel, and rests upon a foundation of solid rock. A large amount of excavation was necessary, 90,000 cu. yds. of earth and rock being removed. A 70-ton steam shovel with a 2½-yd. dipper fitted with Panama teeth was used. Digging began at the shore end in April, 1910, and trains of dump cars hauled by locomotives transported the excavated material to form an earth fill on either side, making new ground beyond the original shore line.

To cut off the water during construction a cofferdam 900 ft. long was built in the shape of a horseshoe surrounding the site on three sides, as shown in Fig. 4. Two pile drivers, working in opposite directions from the portal end, drove round piles in two parallel rows 900 ft. long, forming an enclosure around the entrance end 300 ft. wide. These piles were spaced 3 ft. c. to c., and formed an outer and inner fence for the 6×10-in. and 2×10-in. sheet piling which was afterwards driven to rock. Waling strips 8×12 ins. were used for the sheet piling and round pile wales were used for the outside. Steel tie-rods were placed across the cofferdam at intervals of 3 ft. On top of the round piling and sheet piling a framing was constructed of 8×12-in. timbers, on which a temporary track was laid. As fast as the sheet piling was driven, earth filling was carried out by means of trains of dump cars operated by small locomotives. The resulting cofferdam was a very stable structure. To pump out and keep dry the dock excavation and the enclosure formed by the cofferdam three pumps were installed.

The cofferdam completed, excavation was carried to rock throughout, enough shale and igneous rock being removed to level the basin. Six drills and a 5-in. well-boring machine comprised the drilling outfit.

The concrete work was done very rapidly, due to

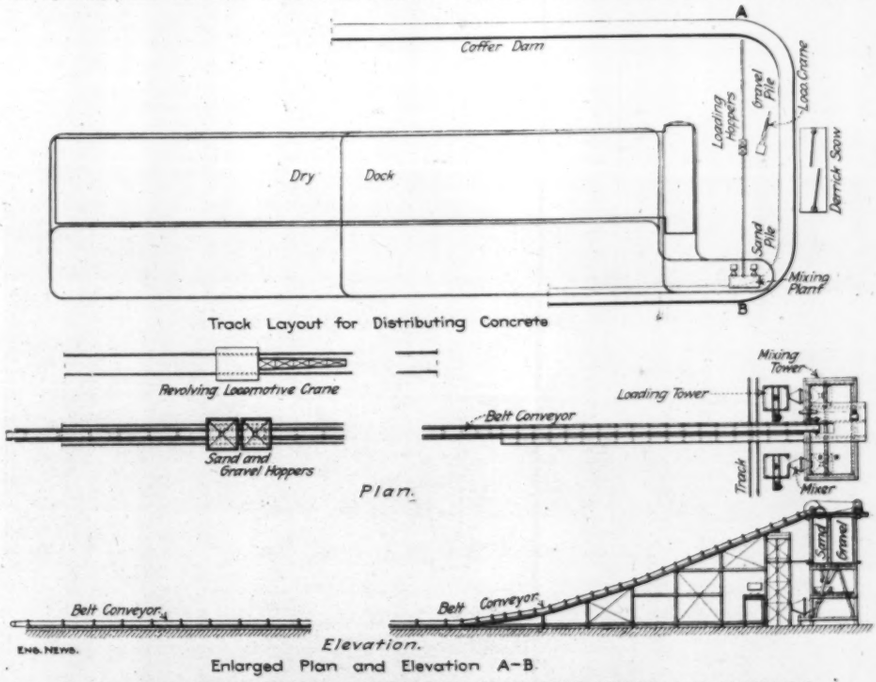

FIG. 4. ARRANGEMENT OF CONSTRUCTION PLANT FOR MIXING AND HANDLING CONCRETE; PORT ARTHUR DRY DOCK.

the organization of the working forces and the efficient arrangement of the plant. The arrangements were so simplified that from the dredging to the final pouring of concrete the work was continuous. The arrangement of the construction plant is shown in Fig. 4. Scows of 1,000 yds. capacity, fitted with derricks and clamshell buckets, dredged sand and gravel from Lake Superior at about 60 miles from the site, and unloaded it at the portal face upon the coffer-dam, on either side of a locomotive crane. Two hoppers placed over a 24-in. conveyor belt (electrically driven) received the materials from the crane bucket and alternately fed the belt, which led to the mixer tower. This had two receiving hoppers for sand and gravel, and below these were two charging hoppers. The latter received the proper quantities of sand, gravel and cement for separate batches of concrete, and the whole charge was run into one of the two mixers below. A new charge was immediately prepared, and this in turn was run into the second mixer. In this way it was possible to have the plant working to its full capacity without intermission.

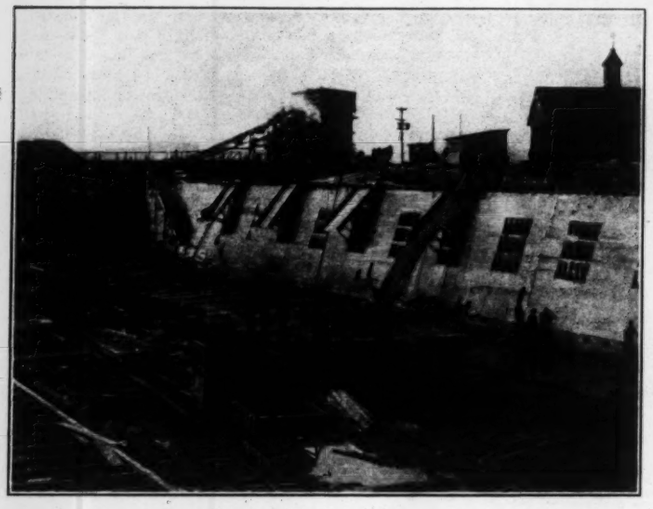

FIG. 5. DEPOSITING CONCRETE BY CHUTES FOR THE FLOOR OF THE DRY DOCK: (SHOWING THE CONCRETE MIXING PLANT).

The concrete after being mixed was elevated by a bucket hoist and delivered into V-shaped steel dump cars of 1-yd. capacity on a track running along the top of the forms for the dock wall. From the cars the concrete was poured directly into the forms. The tracks were laid in a number of loops, crossing the dock excavation on trestles so that there was no confusion in returning empty cars to the mixers (Fig. 4). By this system as much as 1,000 yds. of concrete was placed by two shifts in one 24-hour day. Fig. 5 shows the concrete for the floor being shot into place from the dump cars.

The forms for the side walls were made in small sections for convenience in handling. Each section was 5 ft. wide and extended the full height of the wall. Seven of these were placed together and bulkheads were attached at each end. In this way a section of the wall 36 ft. long could be poured, making a huge monolithic block. Alternate 36-ft. lengths were first built and when the concrete had finally set the intermediate sections were poured. An expansion joint was formed for every 36 ft. of length and so cracking was obviated. Fig. 6 shows the forms in place on one side, while at the end of the dock may be seen the sand and gravel piles and the concrete mixing plant.

The dock proper is 85 ft. 4 ins. wide at the floor level and 98 ft. 8 ins. at the top of the walls. It is 700 ft. long, and a further length of 28 ft. 6 ins. within the portal or entrance may be utilized. Spaced every 18 ft. in the side walls are three altar steps, designed to hold lateral bracing to support vessels in the dock. The floor is of solid concrete from 2 to 4 ft. thick, sloping towards a central drain which terminates in a rudder well at the portal end. From the rudder well, a drain protected by an iron grating gives access to the pumping well situated in the west portal pier. With a view of future extension this drain was duplicated on the opposite side of the pumping well, so that when a second dry-dock is built (parallel to the present one) the pumping outfit will serve for both docks.

The portal walls are solid masses of concrete faced with concrete of a 1:3:5 mixture, which is used also in the side walls. The outside corners are curved and are protected from injury by steel plates firmly attached by anchors of steel angle anchors imbedded in the concrete. The portal jambs and sills are faced with steel. Angles 6×6×¾ ins. firmly fastened to the concrete floor by 3×3×½-in. anchors 4 ft. long (spaced 2 ft. apart) form a connection for the 16×¾-in. plate against which the heavy steel gate or caisson rests (Fig. 7). Strong lateral anchors embedded in the portal piers hold the jambs in position. Great care was exercised in placing this steel framework to obtain a truly vertical and longitudinal alinement.

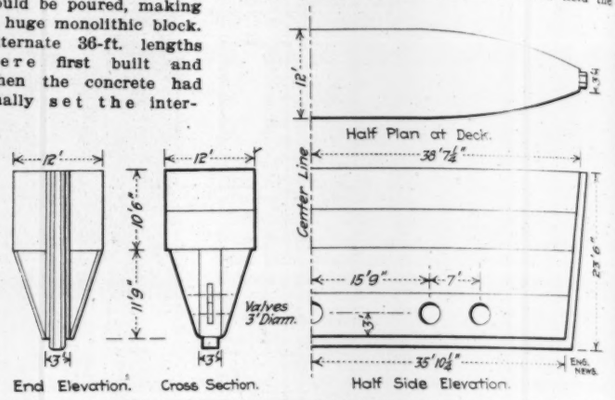

FIG. 7. FLOATING GATE OR CAISSON FOR THE PORT ARTHUR DRY DOCK.

A feature of interest is the construction and arrangement of the bilge and keel blocks with their attachments. The slides upon which the bilge blocks move are spaced 12 ft. apart on each side of the dock; they are made of 3×14-in. white oak timbers bolted every 2 ft. Split anchor bolts ¾×18 ins. fasten them securely to a concrete base, and the nuts are countersunk so as to leave a smooth upper surface on which the bilge blocks slide. These blocks are 4 ft. 6 ins. in height, made of 12×12-in. Oregon fir timbers. They are drift-bolted together at the ends and are furnished with slide irons and wooden slide blocks clamping them to the slides. Two hauling chains are attached to each block by means of U-bolts and two fair leaders are attached to the dock wall, one at the lower angle and the other near the top. The keel blocks, constructed of 12×12-in. white oak timbers fastened together with 1×20-in. lag screws, rest on a 12×14-in. white oak timber set in the concrete floor and fastened thereto with 24-in. expansion bolts. These are spaced 6 ft. apart and extend from the rudder well to within 12 ft. of the shore end of the dock.

Concrete sidewalks 5 ft. wide run the full length at each side, and four reinforced-concrete stairways lead from their ends to the top of the dock walls.

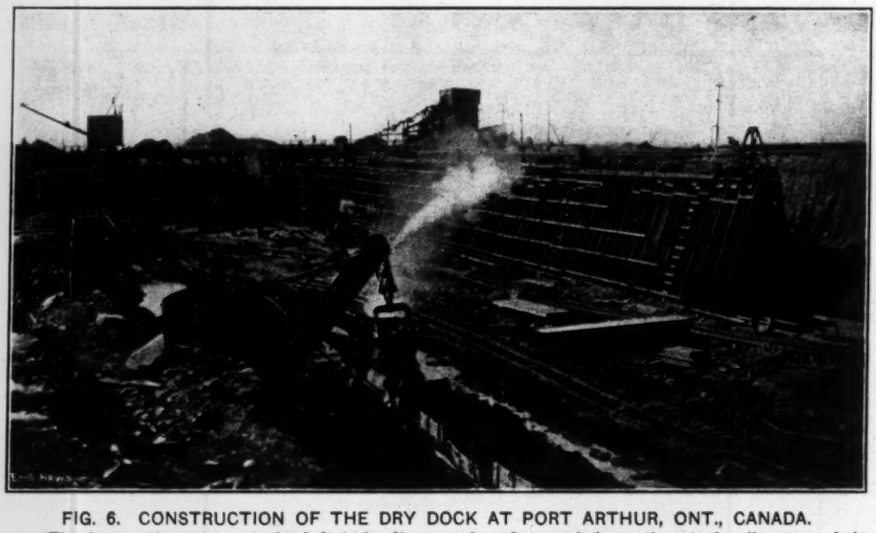

FIG. 6. CONSTRUCTION OF THE DRY DOCK AT PORT ARTHUR, ONT., CANADA.

(The locomotive crane at the left is loading sand and gravel from the stock piles to a belt conveyer which rises on an incline to the bins of the concrete mixing plant at the right. The forms for one wall of the dock are shown in place; the sides of the wall are sloped instead of stepped, as shown on the plans. The track for the concrete dump cars runs on the top of the forms.)

The Use of Chlorine (hypochloride) to treat the water supply of Paris during the past season is reported by Mr. John Ritchie in the course of a contribution entitled "Notes on a Medical Turn about Paris," printed in the Boston (Mass.) "Evening Transcript" of Oct. 8. It is stated that this fact was brought out during a discussion of a recent outbreak of typhoid fever in a suburb of Paris, from which it was learned that on account of a scarcity of spring water in August, 1911, it became necessary to draw 8,000,000 gals. daily from the Marne; this water "was sterilized by means of chlorine." Later, it was disclosed that previous to this similar treatment of the water from the springs of the Vonne had been instituted, owing to a suspicion of the character of the water.

A Speed-Reduction Gear and Transmission Dynamometer.*

The development of the Melville-Macalpine speed-reduction gear to be interposed between a steam turbine and a ship's propeller has already been noted at length in Engineering News (Oct. 21, Dec. 9, Oct. 30, 1909; April 7, 1910). It will be recalled that the feature of greatest novelty in these designs has been the "floating frame"

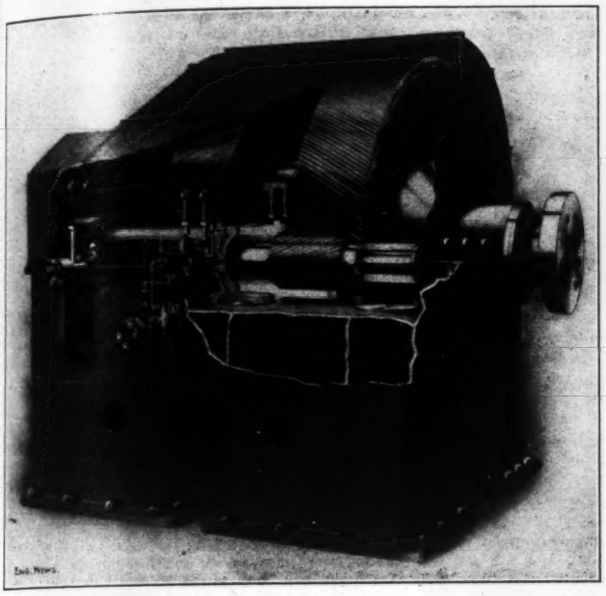

FIG. 1. THE NEW TYPE OF MELVILLE-MACALPINE SPEED REDUCING GEAR, AS BUILT FOR THE U. S. S. "NEPTUNE."

in which the pinion bearings were held. This was a girder stiff against simple horizontal and vertical motion but fastened only at the center of the base to allow a slight rotational flexure in a vertical plane through the pinion axis. By such slight movement inequalities in tooth contact were to be prevented.

A departure from that design is shown in the geared turbines furnished for the U. S. S. "Neptune." The floating-frame idea is retained and its name now truly describes it, since it is oil supported. The thrust of the gears on the shaft bearings is, of course, transmitted to the oil chambers and the oil pressure indicates torque and (in connection with speed) horse power.

Fig. 1 is a perspective view—partly in section—of one of the gears installed on the collier "Neptune." Each gear transmits approximately 4,000 HP. at a speed of 1,250 r. p. m. for the turbine shaft, and about 130 r. p. m. for the propeller shaft. Naturally, double helical gears are used on account of the quiet running qualities of this type, and the fact that the opposing helices automatically balance the end thrust.

The low-speed gear shaft rests in bearings seated in the main casing, and up to this point the design is fairly conventional. The essential and distinctively novel feature of the design is the hydraulically supported frame which carries the pinion shaft and its bearings, and by virtue of which the pinion shaft is self-aligning, responding instantly to the smallest unbalancing of the tooth pressure. With this method of suspending the pinion-bearing frame, the fluid cushion interposed between the pinion shaft and the main casing of the gear silences in a large measure the noise usually associated with the operation of high-speed toothed gearing, and prevents all shock or jar from the rapid contacting of the teeth. After a considerable period of operation, the gear teeth take on an excellent polish and show no signs of pitting or other deterioration that usually accompanies hard and continuous service.

*From information supplied by Mr. H. E. Longwell, M. Am. Soc. M. E., Consulting Engineer, Westinghouse Machine Co., East Pittsburgh, Pa.

The action of this floating frame may be more easily understood from Fig. 2, which is purely diagrammatic. Detail sections are shown in Figs. 3 and 4, and the same symbols are used in all of the illustrations. *A* represents the frame carrying the bearings of the pinion shaft, *D* is a portion of the main casing, and *E* is a rigid strut or beam secured to the main casing by means of a series of steel columns which are shown in Figs. 1 and 3. It will be noted that *A* does not fit closely between the parallel faces of *D* and *E*, but has freedom for a slight upward and downward movement. On the upper and lower surfaces of *A*, are three circular pads bored out to form shallow cylinders in which are fitted short pistons *C*. A passage or port which communicates with the three shallow cylinders on the lower side of the frame *A* is indicated by 1, and 2 is a similar port communicating with the corresponding cylinders on the top side of *A*.

When the gear is working, the reaction on the pinion teeth will tend to force the frame *A* against the casing *D* or the beam *E*, depending on the direction of rotation. If the reaction on the pinion teeth tends to force the frame *A* downward against *D*, then if oil or other suitable fluid under sufficient pressure be introduced at 1, it will be readily seen that the frame *A* will be lifted clear of the casing, and will actually float on the fluid in the cylinders. Similarly, if the direction of rotation be reversed so that the tendency is to force the frame *A* against the beam *E*, the introduction of fluid under pressure at 2, will prevent the frame *A* from coming in actual metallic contact with *E*. Since all three cylinders of the set that may be in action are connected to the same source of fluid supply, the slightest difference in tooth pressure on either side of the middle point of the pinion shaft *F* will cause the frame *A* to yield at the point where the pressure is unduly high. In thus yielding, the excess pressure is relieved, and automatically transferred to the point in the working face of the pinion at which the tooth pressure was, at the instant, below normal.

The underlying principle of this design is seen to be the supporting of the pinion shaft in a frame which literally floats on oil, and which has no metallic or other rigid connection to the main casing. The practical application of this principle involves an accurate and automatic regulation of the fluid pressure in accordance with the load on the gear. How this is accomplished may be understood from a study of Figs. 3 and 4.

Fig. 3 is a transverse section through the floating frame at the middle bearing. The frame is split in a horizontal plane for convenience in removing or inserting the shaft and bearings. The passages 1 and 2 communicate with the supporting cylinders, and 6 is a duct which conveys lubricating oil at low pressure throughout the length of the pinion frame and distributes it by means of side outlets, to the bearings, and to the pinions. *B* is an arm which projects into the valve box *G*, and which contains passages communicating with 1 and 2. *H* is a link which hinges the frame *A* to the casing *D* so that the slight vertical motion of the frame is multiplied at the end of the arm *B* which controls the oil valves.

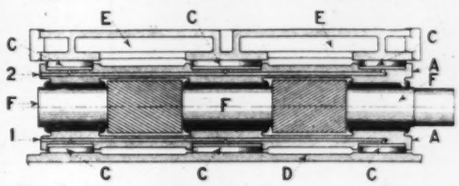

Fig. 2. Diagram Showing Operation of Floating Frame.

For many years it has been known in a general way that if oil be fed to a rotating journal at the point of minimum pressure, it will be carried by the journal to the point of maximum

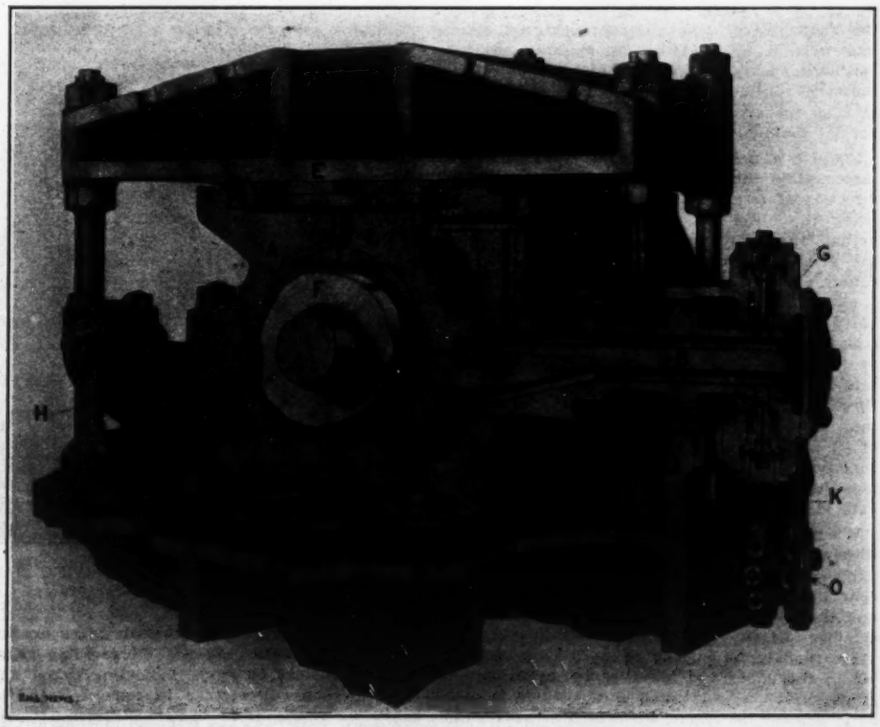

FIG. 3. TRANSVERSE SECTION THROUGH TURBINE AND PINION SHAFTS AND FLOATING FRAME; REDUCTION GEARS OF U. S. S. "NEPTUNE."

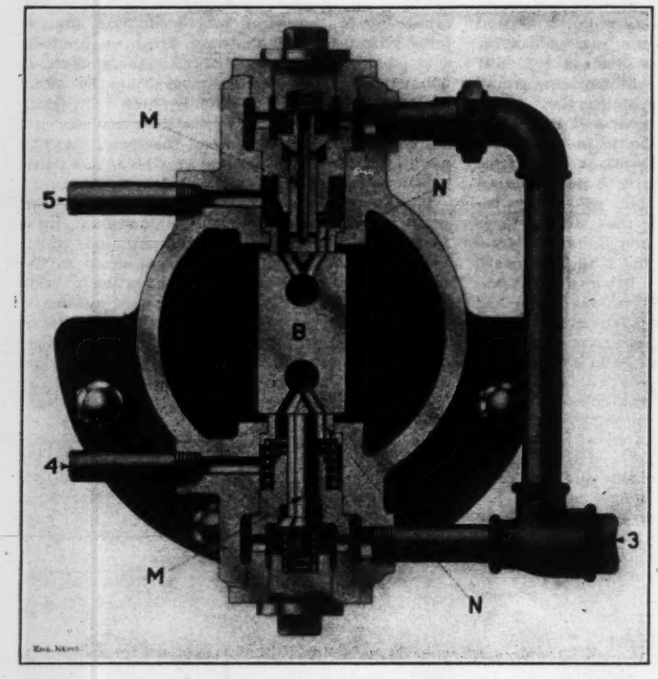

FIG. 4. SECTION THROUGH VALVE BOX OF REDUCTION GEAR.

pressure, and if a means of egress is provided the oil may be discharged against a pressure substantially equal to the maximum bearing pressure. Heretofore, practically nothing has been known, however, regarding the quantity of oil that might be so pumped through a properly designed bearing. In the development of this gear, it was found that by suitably proportioning the bearings and supporting pistons, the former could pump all of the oil required for floating the pinion frame.

Referring to the section through the bearing as shown in Fig. 3, it will be seen that there are small passages connecting the top and bottom of the bearing with the upper and lower cylinders respectively. The bearings draw in oil from the lubricating system, and discharge it through the check valves *L* into the supporting cylinders, and were it not for the automatic regulating mechanism in the valve box *G*, would build up a pressure considerably greater than is required to keep the pinion bearing frame floating in its normal position.

Fig. 4 is a cross section (at 90° to Fig. 3) on a larger scale through the valve box *G*. If the direction of rotation of the pinion is such as to bring the lower set of balancing cylinders in action, the excess pressure will tend to raise the arm *B* slightly, and as the ring valve *N* cannot follow it on account of coming up against a shoulder, the surplus oil will escape into the valve box.

In Fig. 3, *J* is a floating packing which prevents the overflow oil from spilling directly back into the main casing, and compels it to run off through the drain pipe *K*. This pipe discharges into an open funnel, and the constant overflow of oil is an unfailing indication that the gear is functioning properly. From this funnel the oil may be returned to the main casing to be circulated again through the lubricating system.

When starting, it may be desirable, though not absolutely necessary, to supply the oil to the supporting cylinders from an outside pressure source, until the gear attains the normal speed, and the pumping action of the bearings is fully established. Oil from such an outside source of pressure may be introduced at 3 (Fig. 4) and led to the upper and lower valves as indicated. If the direction of rotation of the pinion is such as to depress the frame, the arm *B* depresses the ring valve *N*, and the conical valve *M*, pushing the latter from its seat. The stem of the valve *M* is hollow, as shown in the section through the upper valve. When the valve *M* is opened, the oil passes through the hollow stem into the lower circular port in *B*, and thence to the passage 1 (Fig. 3) which connects with the lower set of cylinders, and is prevented by the check valves *L* from escaping into the bearings. When the balancing pressure has been attained, *B* rises to its neutral position, allowing *M* to seat and prevent further entrance of oil. If, by reason of a reduction of the load, the oil pressure in the supporting cylinders becomes excessive, *B* rises slightly above its neutral position, relieving the excess pressure in exactly the same way as when the oil is being pumped by the bearings. The total movement of *B* for adjusting over the entire range of load is only a few thousandths of an inch.

When the direction of rotation is reversed, the operation is just the same, except that the necessary functions are performed by the upper valves instead of the lower ones.

From the foregoing description, it will be seen that the oil pressure in the supporting cylinders is always exactly in proportion to the thrust on the bearings and to the torque that is being transmitted. Therefore, a simple pressure gage connected inside of the valve *M* will indicate the instantaneous load on the gear, if the speed in revolutions per minute be known, so that this reduction gear is an accurate and sensitive dynamometer as well.

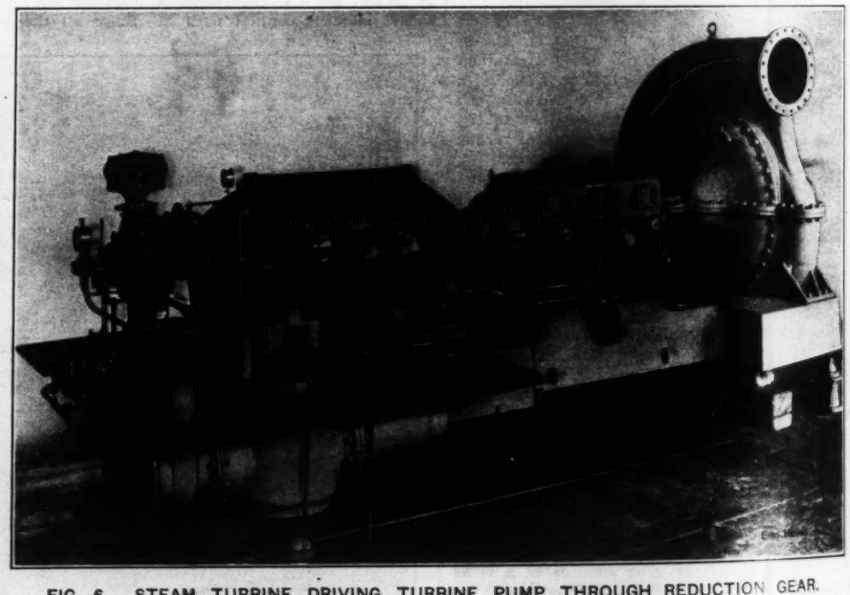

FIG. 6. STEAM TURBINE DRIVING TURBINE PUMP THROUGH REDUCTION GEAR.
(Single-stage 24-in. 715 r.p.m. 20,000,000-gal. 140-ft-head Platt Iron Works pump and Westinghouse double-flow 3,000-r.p.m. turbine.)

The connections to the pressure gages are indicated at 4 and 5 (Fig. 4). If recording gages are used instead of simple indicating gages, and a graphic speed recorder is connected to the gear, the charts from these instruments would constitute a continuous log of the power transmitted. The pressure gages may be located in any convenient position, and as far away from the gear itself as may be desired. The direction of rotation is always evident from an observation of which of the two gages is indicating pressure at the time. If the gages were placed at any considerable height above the gear, their indications would have to be corrected for the hydrostatic head of the oil column. Furthermore, if the gages were located at a great distance from the gear, there might be some annoyance from leakage, solidification or air pockets in the oil piping. For long-distance indications, a device (*O*, Fig. 3) has been worked out, to translate the oil pressure to a compressed-air supply, which may be conducted to the pressure gages wherever they may be located.

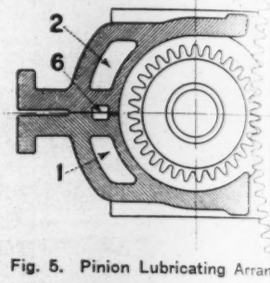

Fig. 5. Pinion Lubricating Arrangement.

Fig. 5 is a section through the floating frame and pinion and illustrates the simple way in which the lubrication of the gear teeth is accomplished. The frame encloses the pinion except for a portion of the circumference where the teeth engage with those of the large gear. From the passage 6, lubricating oil passes to the pocket in which the pinion is located. The shape of this pocket is such that the oil cannot run out, but must be picked up by the teeth of the pinion. The oil, when picked up by the pinion, is thrown off again by centrifugal force, but it is discharged directly into the teeth of the large gears at the point of engagement.

In Fig. 1, at the left of the casing, is shown a bracket through the upper end of which is a screw-adjusted strut, bearing against the pinion frame. A similar bracket and strut—not shown in the illustration—are located at the other end of the casing. These struts are for adjusting and maintaining constant the depth of engagement of the gear teeth; they do not interfere with the movement of the pinion frame in a vertical plane.

In order to obtain a flexible drive between the

turbine and the gear, and at the same time to keep this gear in close proximity to the turbine, the pinion shaft is made hollow, and the driving shaft passes freely through this bore and is connected to the pinion shaft at the end farthest away from the turbine. This is an old and fairly well known construction, which has been incorporated on account of its making the apparatus more compact, and not because of novelty.

While the Westinghouse reduction gear was originally designed for marine propulsion, its adaptability is claimed to have opened up a still broader field. In addition to the two 4,000-HP.

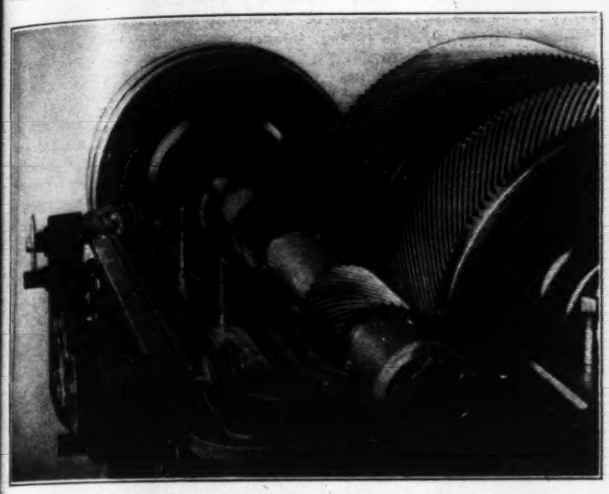

FIG. 7. REDUCTION GEAR FOR STATIONARY SERVICE: COVER AND UPPER HALF OF BEARINGS REMOVED.

gears installed on the "Neptune," twelve 1,000 and 2,000-HP. sets have been made by the Westinghouse Machine Co. for driving direct-current generators and other apparatus such as large centrifugal pumps. A number of these have already been in service for some months, with the turbines running at speeds as high as 3,600 r. p. m. For such service, in which the direction of rotation is never reversed, only one set of balancing cylinders and regulating valves is required. One of these gears is shown in Fig. 7 with the cover and upper half of pinion bearings removed.

The Naval Expenditures of the principal naval powers of the world show steady increases during the last three years. With the exception of the United States the sum expended by each nation during the present year will be several millions more than that of the previous year. A compilation made by the British Admiralty of the sums voted or expended for naval purposes by the principal nations for the present year are as follows:

Great Britain	$218,000,000
France	81,000,000
Russia	64,500,000
Germany	107,000,000
Italy	40,600,000
Austria-Hungary	25,000,000
United States	129,000,000
Japan	42,600,000
Total	$707,700,000

The total naval expenditures of these eight nations during the last three years amount to the immense sum of $1,970,000,000.

The number of persons in the various navies is given as follows:

Great Britain	134,000 men
France	58,649 "
Russia	46,655 "
Germany	60,805 "
Italy	30,587 "
Austria-Hungary	17,277 "
United States	62,283 "
Japan	49,389 "
Total	459,645 "

In round figures it is costing these eight nations nearly three-quarters of a billion dollars a year to build, equip and maintain their war vessels and to support and pay the wages of nearly half a million men.

Comparative Merits of Cast-Iron and Steel Pipe.*

By NICHOLAS S. HILL, JR.†

My remarks will be confined, as were those in the paper under discussion,* to the relative value of cast-iron and steel for large supply mains, as nothing has been developed which so readily adapts itself to street distribution mains of smaller size as does cast-iron.

In first cost steel mains of large size are cheaper than cast-iron mains. As a rule they are more easily handled because lighter.

The question of strength is one of design; and in making comparisons it should be assumed that both the cast-iron and riveted-steel pipe will perform the function for which they are designed.

From the data available, it appears that the cost of maintenance and depreciation on cast-iron pipe is less than on riveted-steel pipe. The data at hand, however, is not sufficient to enable one to say definitely that the difference is sufficiently great to offset the difference in interest charges resulting from the additional first cost of the cast-iron pipe. Interruptions to service where a community depends upon a single supply line, resulting from repairs as a result of corrosion, are usually of more importance, however, than the mere consideration of cost.

Experience has shown that the more nearly steel approaches a pure iron, the longer it resists corrosion. The properties of wrought-iron are the nearest approach to pure iron, notwithstanding its slag. This is because the slag is mechanically mixed and does not interfere with the chemical properties of the product.

Investigations by a Committee of the American Society of Testing Materials have failed to produce any conclusive evidence with regard to the relative rapidity with which wrought-iron and steel corrode; so many elements seem to affect the rate of corrosion. Field experience, however, indicates that the riveted pipe of wrought-iron is more resistant than steel. In considering this question, it must be remembered that it is difficult to obtain wrought-iron plate at this time, and that in specifying riveted pipe, low carbon steel should be considered.

Cast-iron is more highly resistant to corrosion than either steel or wrought iron. Every examination which I have made of steel and cast-iron mains, laid under the same conditions, has fairly demonstrated the greater resistance of cast-iron pipe to corrosion.

The greater resistance of cast-iron to corrosion than steel is probably due, in a large measure, to the silicious coating which it receives when the molten metal is poured in the mold. The silicious coating adheres very firmly to the pipe. Also the roughness of the exposed surface of the cast-iron offers a firmer foundation for the coating than does the smooth surface of the steel pipe, and hence the same coating applied to cast-iron is usually more durable than when applied to steel pipe.

We have much data with relation to the life of cast-iron pipe. We know that it is good for a hundred years when properly coated, and under almost any condition of soil. There are instances of much longer life.

The intake pipe at the first pumping station for supplying Paris (which extended into the river Seine, and which was laid in 1802), after an immersion lasting for over a century, was recently removed and was found to have been in such good condition that it might have been relaid. The lettering on the pipe was not disturbed. Instances of cast-iron pipe laid in Europe as early as 1765, which is now in serviceable condition, have been recorded. The speaker has removed cast-iron pipe from low ground saturated with a salt solution which had been in service since the early part of the last century and which was in excellent condition when removed. There appears to be no practical limit to the endurance of cast-iron pipe and its resistance to ordinary corrosion.

In considering the effects of corrosion, reference must be made to the effects of chlorides, nitrates and sulphates, which are found in soils of high organic content, and in marsh lands adjacent to salt water. Weak solutions of these salts will produce harmful effects, proportionate to the rapidity with which a material will corrode. A minute quantity of soluble salts is sufficient to start corrosive action and a material which is liable to corrosion should not be placed therein.

Reference has been made to the life of cast-iron pipe. Experience with riveted-steel pipe is very much more limited but there are examples which tend to show that lines of riveted-steel pipe, constructed within the last 20 years, have materially depreciated and great trouble has been experienced from the effect of corrosion. These effects seem to proceed more rapidly in clay soils and marsh land than in sand. Among the pipes which have thus been affected, is the second Hemlock Lake conduit, in Rochester (N. Y.), which was laid in 1893; the Portland (Ore.), conduit, the Atlantic City conduit, and certain conduits laid in the marshes of the Hackensack meadows in New Jersey.

Electrolysis is manifestly more rapid on steel pipe than cast-iron pipe, for the reason that steel will corrode more rapidly than cast-iron, and electrolysis may be defined as a more serious form of corrosion, occurring where an electric current leaves the pipe and which, in so doing, sets up corrosive electrolytic action.

Rolled steel plates, as compared with cast-iron, although the cast-iron is several times as thick, will, owing to the higher conductivity of steel, have from one to three times the conductivity of a cast-iron pipe designed for the same pressure. This is important, as the electrolytic action is mainly dependent upon the volume of the current, and hence in territories where street railway currents are returned over pipe lines, the riveted-steel pipe offering a better conductor will carry more current, and hence electrolytic action will be aggravated on this account.

There are few places of any size, in which the suburbs are not, at the present time, traversed by numerous suburban lines. If the mains pass in the vicinity of these lines, they may absorb their proportion of the return trolley current and deliver it to the ground at some point nearer the power station. This was clearly demonstrated to me in a recent survey of certain steel and cast-iron pipe lines laid in the marshes of the Hackensack meadows. I found that these pipes were carrying quite an appreciable quantity of current from distant points to the power station, and that they were unloading it in the marshes, to be returned through the saturated soil, to the power station. The result of these surveys indicated the superior conductivity of the steel pipe, and the much greater corrosion resulting from the effects of electrolytical action, than in the case of the cast-iron mains.

In summing up, it may be said: (1) That where first cost is of prime importance, steel may be used on large supply mains. (2) Where the difficulties of transportation are serious and the cost of hauling is heavy, expediency may call for the use of this material. (3) In sections where dry sandy soil is encountered, one would be justified in securing the benefit of reduced first cost by recommending steel pipe. (4) In clay and wet soil, such as marsh lands and meadows, particularly where the presence of salts in solution increases corrosion, riveted-steel pipe should not be used. (5) Where pipe is laid in wet soil and will be subject to electrolysis, cast-iron should be used. (6) Where permanency is a prime consideration, our present knowledge indicates that cast-iron is preferable.

*Condensation of a discussion of a paper with the same title by Mr. Allen Hazen, M. Am. Soc. C. E., read before the American Water Works Association in June, 1911; see Eng. News, June 15, 1911, for an abstract.

†Consulting Engineer, 100 William St., New York City.

A Train-Lighting Instruction Car has been placed in service by the Pennsylvania R. R., for the instruction of employees. This company has at present eight distinct axle lighting systems, in addition to several arrangements of storage-battery equipment. It is intended to send this car to different points where yard electricians are maintained. The equipment of the car consists of a 32-cell storage battery, a 15-KW. Curtis turbo-generator, a variable-speed motor with control apparatus for driving the several axle generators, and six makes of the latter with regulating equipment.

The Design of Masonry Dams: Should Hydrostatic Pressure Underneath and Ice Pressure be Included?

By EDWARD WEGMANN,* M. Am. Soc., C. E.

In an article that appeared in Engineering News of Oct. 19, 1911, Mr. John R. Freeman, M. Am. Soc. C. E., states some ideas suggested by the failures of the two Austin dams. With most of Mr. Freeman's conclusions, engineers will fully agree, but there are two points mentioned which are debatable. The first of these is the deduction that an upward pressure under the base of a masonry dam should hereafter always be considered in designing the profile. Mr. Freeman says:

> From what I have seen at the two Austin Dams I shall in the future be inclined to impose the further criterion of ability to withstand the full static pressure of the water from the upstream side penetrating with undiminished force to nearly the downstream face or toe of the dam.

The second debatable conclusion is that an allowance of 10 to 25 tons per lineal foot of the dam for ice pressure should be made in a northern latitude.

The effect of including upward pressure under the base of the dam and ice pressure is to increase very much the area of the profile of the dam. In 1895 Mr. John D. Van Buren, M. Am. Soc. C. E., advocated in a paper on "High Masonry Dams" (see Trans. Am. Soc. C. E., Vol. XXXIV., p. 493) that the profile should be designed by taking into consideration the full upward pressure, due to the head in the reservoir,

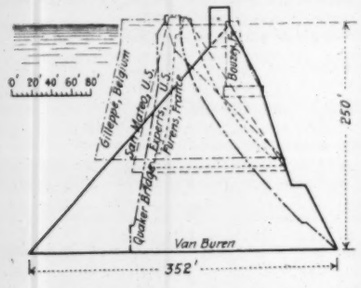

Fig. 1. Cross-Section of Masonry Dam to Withstand Ice Pressure and Hydrostatic Uplift; Proposed by John D. Van Buren, 1895.

under the base of the dam, and, also, in northern latitudes, an ice pressure of about 40,000 lbs. per lineal foot of dam. Based upon these conditions, which agree closely with those suggested by Mr. Freeman, Mr. Van Buren arrived at the profile shown in Fig. 1, which has a base of 352 ft. for a height of 250 ft. For comparison the profiles of a few famous dams are also given.

It was the writer's privilege to assist the late Alphonse Fteley, Past President Am. Soc. C. E., in making the calculations and preliminary studies for the proposed Quaker Bridge Dam, which was built in 1892-1907, about 1¼ miles above the old Quaker Bridge, and was given the name of New Croton Dam.

Mr. Fteley, who had had large experience in the construction of dams, was strongly of the opinion that with a deep foundation on good, practically impervious rock, upward pressure under the base or at any assumed horizontal joint need not be considered, as it would only exist, if at all, over a very small area of the whole base or joint. While fully aware that some water would percolate through even the best masonry dam, he considered that such water passed through the masonry by a capillary action, and did not exert a hydrostatic pressure. He knew that temperature cracks would occur, but he did not consider that the pressure of the water entering such cracks would exert a material effect on the stability of the dam. These cracks in dams in the Croton watershed, built without expansion joints, are nearly vertical.

Mr. Fteley thought, also, that in a reservoir with sloping banks, having the dam in a gorge, and with the climate of the Croton watershed, ice would not produce a considerable pressure against a dam, but would shove up on the banks and break.

In designing three important dams for impounding water for the supply of the city of New York, Mr. Fteley neglected all upward pressure and ice pressure, and certainly the closest inspection of these structures will fail to detect any sign that would indicate that Mr. Fteley was mistaken. The dams referred to are: the Sodom Dam, 98 ft. high, built 1888-1893; the Titicus Dam, 135 ft. high, built 1890-1895; and the New Croton Dam, 297 ft. high, built in 1892-1907.

If the last mentioned dam had been designed to resist a full upward pressure under its base and an ice pressure of 40,000 lbs. per lineal foot of dam, its base would have been over 400 ft. wide instead of 206 ft., as actually built.

The distinguished French engineers who designed and built the Furens, Ban, Ternay dams, and many others, disregarded upward pressure under the base of the dam and ice pressure, although in the case of the Furens Dam, thick ice forms in winter.

On the other hand, these forces have been taken into account in some recent dams in America. The first masonry dam whose profile was determined by assuming a large upward pressure under the base, and, also, ice pressure near the top was the Wachusett Dam, built in Massachusetts in 1900-1906 under the direction of Mr. Frederick P. Stearns, M. Am. Soc. C. E., as Chief Engineer. In this case, the ice pressure was assumed to be 47,000 lbs. per lineal foot of dam and the upward pressure under the base was taken as two-thirds of the full hydrostatic pressure at the upstream face and assumed to diminish uniformly so as to be zero at the downstream toe. The effect of these forces in increasing the area of the profile of the dam is shown in Fig. 2, in which the profiles of the Wachusett and New Croton dams are compared.

Some years ago, in discussing the large difference in area between the profiles of the Wachusett and New Croton dams, Mr. Stearns told the writer that a town of 13,000 inhabitants was situated only half a mile below the Wachusett Dam, and that there was a very strong sentiment against building a dam in such a locality, where the consequences of a failure would have been appalling. Under the circumstances, Mr. Stearns said he felt justified in adopting an unusually strong profile. A similar profile was used for the Olive Bridge Dam, which is now being built about 12 miles above Kingston, N. Y., in connection with the Ashokan Reservoir.

Engineers will readily agree that where such great interests are at stake, it is justifiable to make assurance doubly sure by including in the calculations of the profile of a masonry dam every conceivable force that might contribute to the failure of the structure. But is it the best practice to adopt this method generally?

If the question of cost had not to be considered, we would readily agree to this proposition and we might design profiles for masonry dams on the simple principle of making the width, at any level, equal to the height. True skill in engineering consists, however, in obtaining the required security and good architectural appearance at a minimum expense.

Many comparatively low dams of all kinds, built across streams subject to high floods, have been ruptured, either because they were not properly designed as overflow-weirs, or because they were badly founded or constructed. But very few masonry dams, 50 ft. or more in height, have failed. The only cases of such failures that have come to the notice of the writer are given in the following table:

FAILURE OF MASONRY DAMS, 50 FEET OR MORE IN HEIGHT.

Year.	Name.	Location.	Height in ft.	Cause of Failure.
1802	Puentes	Spain.	164	Pile foundation.
1881	Habra	Algiers.	110	High flood—poor masonry.
1895	Bouzey	France.	72	Pervious sandstone foundation.
1900	Austin	Texas.	68	High flood—poor foundation.
1911	Austin	Penn.	50	Now being investigated.

The dam at Montgomery, Ala., is not included in the above table, as the failure that occurred in 1902 was that of a cofferdam surrounding the unfinished closure section of the dam.

Because two or three masonry dams built on shallow foundations of pervious [illegible] have failed, shall we hereafter assume in [illegible] calculations that the dams we are designing [illegible] to stand on such foundations?

To do so in all cases would [illegible] logical. If a dam is to be built on a foundation of porous sandstone in horizontal strata, underlaid by shale, with fissures filled with clay, [illegible] and gravel, it would, doubtless, be necessary in making the design to assume an upward pressure under the base due to the full hydrostatic head of the water at the dam, and to adopt a very low coefficient of friction in calculating the resistance to sliding. In such a place it would be inadvisable to build a solid masonry dam and a hollow dam of the Ambursen or Ransome type would be preferable.

With a good rock foundation of practically impervious rock, a deep foundation trench and care in closing all fissures and seams by grouting, etc., it is not necessary, in the writer's opinion, to assume an upward pressure. If we apply to

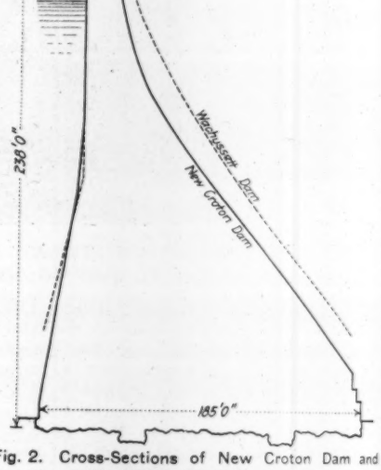

Fig. 2. Cross-Sections of New Croton Dam and Wachusett Dam Compared.

[Contract Section of New Croton Dam Shown. Dam as built same profile but 297 ft. high.]

the masonry dams in the Croton watershed, designed by Mr. Fteley, and to some of the French dams mentioned above, the test of a full upward pressure under the base and an ice pressure of 25 tons per lineal foot, we find that the line of pressure for reservoir full will fall, for the greater part, outside the profile of the dam, and the only force preventing the overturning of these structures would be the tensional strength of the masonry.

The writer recently had occasion to make a careful inspection of the masonry dams in the Croton watershed, mentioned above. They all appear to be in excellent condition and there is not the slightest sign of the masonry having been subjected to a high tensile strain.

In conclusion, the writer thinks that the question whether an upward pressure under the base should be assumed in designing a masonry dam must be determined in each individual case by a careful study of the geological formation on which the structure is to be founded. In masonry dams built without expansion joints and of a character of masonry similar to that of the dams in the Croton watershed, the writer thinks it unnecessary to assume upward hydrostatic pressure penetrating the masonry, as this force will exist, if at all, to a very limited extent. It is possible that in reservoir walls like the Olive Bridge Dam, having vertical expansion joints at regular intervals and built of a stone somewhat different from that of the Croton watershed, that approximately horizontal temperature cracks might occur. If these should be found to go to a considerable depth into the masonry, there would, doubtless, be some upward pressure at the cracks.

As regards ice pressure against a dam, there is

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but little information available. The writer knows of only one case where this force actually moved a dam. He refers to the dam of the Minneapolis Mill Co., which was partly ruptured on April 30, 1899.* In this case, a sheet of ice about 4 ft. thick and 300 ft. wide pressed on one side against a masonry dam (18 ft. high, 12 ft. wide at the base and 5.25 ft. wide on the coping) and on the other side against a retaining wall. During the week the mill pond was lowered and the sheet of ice settled at the center. On Sundays, the pond was filled to its normal level and the ice in rising had somewhat the effect of a toggle-joint, in addition to the pressure due to expansion. Under these special conditions, the dam was actually revolved slightly downstream in the winter. This may have permitted water to get under the base of the dam and have caused 170 ft. of the waste-weir to slide out in the following April.

Ice confined, as it is between bridge piers, exerts a great pressure in expanding, but it seems doubtful whether such a force acts, to any great extent against a dam in this latitude when the shores of the reservoir are sloping. There are many weak mill dams against which ice presses each winter and, yet, we do not hear of their being destroyed. Until we have some more information on this subject, based upon experiment or observation, the writer inclines to the view that in this latitude, ice pressure need not be considered in designing a dam to be built at a narrow part of a valley, to form a reservoir with sloping shores.

The Maximum Dimensions of Ships.†

By Sir WILLIAM H. WHITE,‡ Hon. M. Soc. N. A. and M. E.

It has been thought desirable to initiate a discussion on probable growth in dimensions of ships, and I have been requested to introduce the subject. Having given close attention thereto for many years I have acceded to this request, and have prepared the following notes which may serve as a basis for discussion, although they do not profess to cover the whole ground which may be discussed.

What seem to be chiefly needed are reasoned replies to certain questions:

(1) Is it probable that the dimensions of ships will continue to grow at the rapid rate which has prevailed in recent years?

(2) Will an upper limit to the sizes of ships be reached?

(3) What consideration, if any, are likely to determine such a limit, for either merchant ships or warships?

Since wood ceased to be the chief material for shipbuilding and steam began to supersede sail-power—say about 60 years ago—there has been a complete revolution in the design and construction of ships and an increase in size and speed which was undreamt of by our predecessors. Since the present century began, the rate of growth in dimensions has been much accelerated. This will be seen from the two tables appended. Table I summarizes progress made in the sizes and speeds of transatlantic steamships during the latter half of the nineteenth century; it also enables progress during that period to be compared with corresponding progress during the last ten years. Table II deals similarly with armored warships. In view of the greatly accelerated rate of increase in dimensions which has occurred during the present century and is indicated by these tables, one may well ask, whereunto will this thing grow?

In endeavoring to answer that question some persons resort to simple graphic methods. Dates of construction are used as abscissas and lengths (or tonnages) of ships employed as ordinates. On these data, curves have been constructed whose production, in a tentative fashion, is expected to furnish some indication of what will probably be the dimensions of the largest ships, say, 20 or 30 years hence. Personally, I have no great confidence in this method. It has no scientific basis, it rests upon an assumption that materials and methods of construction, as well as systems of propulsion will remain practically unaltered during the period under consideration; and it presumes that the law of growth will hold continuously. It may be replied by those who favor the method, that it has answered fairly well so far; and that therefore it may be further employed with advantage.

In my judgment, it is necessary to take a broader and more scientific view of the problem if a reasonably approximate solution is to be found. This means ought not to be altogether lacking for reaching a fairly approximate solution, if the conditions of the past and the outlook for the future are carefully considered. The case is not one for treatment by simple "rule of thumb" or more or less arbitrary extension of curves such as have been described; it requires an application of scientific analysis to past experience, and when this has been done the forecast based upon such analysis must necessarily be open to question, and may be falsified by subsequent events. In these circumstances caution is necessary and differences of opinion are justifiable.

Probably the most useful procedure will be to make a detailed statement of facts and principles which will, for the most part, command general assent; and in doing so it may not be out of place for me to state my own conclusions on points of controversy.

I. GROWTH IN DIMENSIONS.—It will be agreed that the law of growth in dimensions has operated hitherto on all classes of ships and that its action has on the whole been beneficial. Members of this society treat as axiomatic the statement that economy in propulsion and over-sea transport has been and always will be promoted by increased dimensions. The actual influence of such an increase has, in many cases, been masked or made less obvious by concurrent changes in other factors and features of ship-construction, but it has been none the less felt. Stronger materials of construction have been made available; more efficient types of machinery and propellers have been devised; higher steam-pressures have led to greater fuel-economy; and higher rates of revolution have favored relatively lighter propelling apparatus. But after each such improvement has been introduced and utilized, the law of growth in dimensions has inevitably reasserted its claims on naval architects, and been again brought into operation in order to secure still further advantage in respect of speed, carrying power, or other features of ship design. Successive vessels belonging to each and every class have been made larger than their predecessors.

Excellent illustrations of this general law may be found in the development of the smaller classes of war-vessels during the last 20 years. In 1892, as Director of Naval Construction, I prepared the first design for so-called "torpedo-boat destroyers" of which so much has since been heard. For the services then contemplated the dimensions thought most suitable were: length, 180 ft.; breadth, 18 to 19 ft.; displacement about 250 tons. The speed on trial was fixed at 26 to 27 knots, and this was sufficient for the purpose the vessels were designed to serve, viz., the destruction of then existing torpedo boats, which were of smaller size and less speed. At that date locomotive boilers were in general use for torpedo vessels, although water-tube boilers were coming into prominence. Marine steam turbines were not known, and quick-running reciprocating engines were necessarily employed. Our knowledge of screw propellers driven at rapid rates of revolution was much less than at present. Oil fuel was not a practical proposition. Mild steel was the best material available.

During the last 19 years the destroyer type has been developed in size and speed and, although the name has been retained, the services for which later vessels have been designed, have not been limited to or even principally concerned with torpedo-boat destruction. In fact the latest vessels in size and armament have grown into practical identity with the seagoing torpedo gunboats (sharpshooters) which I designed in 1887-8 for the Royal Navy as the smallest self-supporting ocean-going type. In speed the later vessels are much superior to torpedo gunboats of earlier date, and this has been made possible by the use of steam turbines, water-tube boilers, oil-fuel, stronger steel and other improvements. There is even now a considerable diversity of opinion as to the value of exceptionally high speed in the type; but in all cases the law of increase in dimensions has prevailed, and vessels classed as destroyers (really sea-going torpedo gunboats) range in speed from 26 to 35 knots, the largest having displacements of about 1,000 tons.

Submarines also furnish illustrations of the working of that law. Boats of the Holland type adopted at the beginning of the century by the U. S. Navy, and soon after adopted for the British Navy, were of small dimensions—63 ft. in length and of 120 tons displacement when submerged, the surface speed being 10 knots. By successive steps British submarines have been increased in size and speed, the latest examples, according to published reports, being nearly 180 ft. long, 800 to 850 tons displacement, and 15 to 16 knots speed. In the United States similar growth in size and speed has taken place. In France the largest submarines of 1901 were about 135 ft. long, 200 tons and 12 to 13 knots speed; vessels now building are 240 ft. long, of 1,000 tons displacement when submerged, and the estimated surface speed is 18 to 20 knots.

The same general law has been at work in the mercantile marine. For each class the average size of ship has been increased, and the fact is apparent in every statistical "return" of the movements of shipping. In 1860 the average gross tonnage of ships (exceeding 100 tons) on the Register of British Shipping was 340 tons; in 1870, 580 tons; in 1880, 1,250 tons; in 1890, 1,570 tons; in 1902, 2,200 tons. Since the Suez Canal was opened the average size of the vessels passing through it has grown steadily; the same may be said of the vessels passing through the Sault Ste. Marie Canal. Every "return" of ships entering and leaving the great ports of the world tells the same tale of growth in dimensions and tonnage. Each annual statement of shipbuilding throughout the world furnishes an illustration of the working of this law. Many small ships continue to be built but there is an universal upward tendency in size.

II. FEW GREAT SHIPS.—It must be noted, however, that, notwithstanding the remarkable developments of the last ten years, the number of ships of extremely large dimensions is relatively few. These great ships naturally attract most attention; they are admittedly essential to the performance of special services; but the carrying trade of the world is mainly done by vessels of moderate dimensions. The British mercantile marine in 1910 owned 11,495 steel ships of 100 tons (gross) and upwards. Of these only 328 ships individually exceeded 7,000 tons (gross), 107 exceeded 10,000 tons and 20 exceeded 15,000 tons. At the same date there were about 5,000 steel ships on the British register of from 2,000 to 6,999 tons gross individual tonnage, and over 6,000 ships of from 100 to 1,999 tons. This enormous preponderance in numbers of ships of moderate dimensions has resulted from the operation of purely commercial considerations, which have similarly influenced all mercantile marines.

Whatever may be the future growth in size of the largest ships built for special services, the bulk of the maritime business of the world will always be done by ships of relatively moderate dimensions, and they will continue to be the largest contributors to the revenues of port and harbor authorities. This fact, as will be shown hereafter, may have an important influence upon the upper limit of dimensions of merchant ships.

III. CONSTRUCTION LIMIT OF SIZE NOT REACHED.—Naval architects will agree that, provided the money is forthcoming for building still larger ships, their construction will be possible, and that considerably increased dimensions will present no serious difficulty even if the materials for shipbuilding already available were not improved upon. Before iron was substituted for wood as the principal material for shipbuilding there was a period—within the recollection of the writer and many of his professional brethren who are still actively at work—when an upper limit of size and engine power seemed to have been reached in wood-hulled ships. Since that date the metallurgists have made great advances and progress is still being made; and on this side there is no bar to immediate and considerable increase in the dimensions of ships. The margin of possibility indeed appears to go far beyond any probable demand.

IV. HARBOR LIMITS ON DRAFT.—Existing physical conditions in the seaports, harbors and docks of the world, necessarily impose limits on the draft of water of ships. Much has been done, at great cost, to improve accommodation and to provide increased depths of water; but it is well recognized that the increase in dimensions of ships above described has been chiefly in lengths, breadths and moulded depths; the increase in drafts of water when fully laden has been relatively small. This is made clear by the figures in Table I. Since 1599, the lengths and depths of transatlantic steamships have been increased

*See Engineering News, May 11, 1899, and Engineering Record, May 13, 1899.

†A paper read at the general meeting of the Society of Naval Architects and Marine Engineers, New York, Nov. 16 and 17, 1911. Copyrighted by the Society of Naval Architects and Marine Engineers. Used by permission.

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about 30%; breadths have been increased nearly 40%, but deep load-drafts by only 10%.

This disproportionate increase in draft of water has imposed difficulties and disadvantages on the work of ship-design which need not be dwelt upon in this gathering. Shipowners find themselves debarred from loading many existing vessels to the full drafts to which they might be safely laden, were there sufficient depths of water at terminal ports and were cargoes available. The earning powers of ships are thus lessened, and in these circumstances it is natural that a demand should have arisen and should still continue, for greater depths of water and better accommodation for ships of the largest size.

While shipowners and shipbuilders urge upon authorities and proprietors of harbors and docks the necessity for prompt and liberal action, the latter may well be pardoned if they do not immediately respond to the demand, but require evidence that the large expenditure which would be needed to carry out these great engineering works will be followed by a corresponding and adequate increase of revenue. The difference in point of view is natural and inevitable. It is idle for those who are interested in ship-development to ignore or treat as unreasonable this attitude of dock and harbor authorities who are responsible for a return to investors on the enormous capital sums administered by them. Of course there are some great works which may be and are properly treated as national rather than private or local enterprises. The Ambrose channel at New York, the St. Lawrence, and the Kiel canal furnish examples; but such enterprises are exceptional in character and are avowedly undertaken for the benefit of the community as a whole, or for strategical reasons which lie outside the present discussion.

V. INCREASED BERTH ACCOMMODATIONS PROVIDED.—Up to the present time the response made to the appeal from shipowners for increased accommodation for larger ships by authorities of the great seaports of the world has been neither niggardly nor unsatisfactory. At the present moment extensive and costly works are in progress which will provide accommodation for the largest ships now building, and leave some margin for further developments. The Ambrose Channel into New York, and the new docks provided at that port for the great transatlantic liners furnish illustrations of the foregoing statement. At Liverpool and Southampton corresponding works are in course of performance, while still larger schemes are contemplated.

It is not necessary to amplify this list, because it is a matter of common knowledge that all over the maritime world the same policy is being followed. Immense sums are being expended on improvements and extensions of docks and harbors, as well as on the approaches thereto, both by governments and by proprietary bodies. One of the latest and largest schemes of this nature is that for the River Thames. From reports issued by the new Port of London Authority, it appears that the estimated outlay for making the dock and channel accommodation of the Port of London suitable for the existing trade, and for providing a proper margin to meet future developments, will be about 14½ millions sterling (over $72,000,000.)

VI. RETURN ON COST OF HARBOR IMPROVEMENTS.—The marvelous growth of the world's commerce in modern times has enabled these great engineering works to be undertaken hitherto under conditions which have, in most cases, either yielded fair returns to investors in dock and harbor securities, or which have been considered by governments beneficial to the whole nation and worthy of adoption irrespective of the return upon capital expenditure.

In many cases this question of dock accommodation has been treated by great corporations, such as railway companies, as parts of their schemes of operations rather than as independent undertakings. Modest returns have been accepted on large sums expended upon docks, because the existence of that accommodation has led to such an increase of earnings on the system considered as a whole, as justified the expenditure on docks.

The growth of traffic in most of the great seaports has also enabled earlier docks to be fully utilized by vessels of smaller dimensions than those for which the latest docks have been constructed. But, while this has hitherto happened, it seems not improbable that a point may be reached beyond which dock and harbor authorities will not care to go in expenditure in order to meet further increase in dimensions and drafts in a relatively small number of the largest ships; and it is well understood that this consideration particularly applies to increase in draft of water, since the cost of dredging grows rapidly with increase of depth.

It is not necessary to amplify this list of what the limit of depth of water will be in future. For the moment 40 ft. of water at low tide seems to be the maximum contemplated; and most ports are content with less, especially when there is a good rise of tide. Keen rivalry between great seaports has hitherto greatly influenced both policy and performance on the part of authorities, and has given shipowners and shipbuilders practically what they have demanded. In the end, however, commercial considerations must prevail, and dividends must be earned by docks and harbors as well as by ships.

In dealing with this matter, therefore, the conflicting claims and interests of all who are concerned not only with shipping, but with docks, harbors, etc., must have due consideration. The advantages to be obtained by the whole community, and not the profit of a particular section, ought and will determine what is done eventually.

VII. DIMENSIONS OF RECENT LOCKS AND DOCKS.—The following brief summary of facts relating to the dimensions of locks and dock entrances recently constructed or now in process of construction may be of interest as indicating the outcome of inquiries set afoot by responsible authorities in regard to the provision of suitable accommodation for the largest ships likely to be built. On the Panama Canal the locks are 1,000 ft. long, 110 ft. wide, with 40 ft. of water over the sills. On the reconstructed Kiel Canal the locks are to be 1,080 ft. long, 147 ft. wide, with 36 ft. of water over the sills, but provision has been made in the structures for increasing this to 46 ft. if required hereafter. The new Gladstone Dock at Liverpool is to be capable of receiving the Cunard steamship "Aquitania" when she is completed, and still larger vessels; it is really part of a great scheme of dock extension. This dry-dock will be 1,020 ft. long, 120 ft. broad, with 44 ft. of water on the sills at high water, ordinary spring tides. On the Clyde, a dock of nearly the same dimensions as the Gladstone Dock is now under construction, with 36 ft. of water on the sills at high water, but the rise and fall of tide is less than at Liverpool. The Port of London Authority contemplates the construction of a dock 1,000 ft. long, 120 ft. wide, with 40 ft. of water over the sills. At the new naval base which the British Admiralty are constructing at Rosyth (Firth of Forth), the plans originally provided for a lock 850 ft. long, 110 ft. wide, with 36 ft. of water at low tide, and for a dry-dock of similar dimensions except that it was to be 750 ft. long. It is understood that some increase in length and breadth is probable.

Approach channels have been deepened considerably. A depth of 40 ft. at low water is to be secured throughout the Ambrose Channel; at Southampton, access is to be secured at all times for ships drawing 34 to 35 ft. At Liverpool the minimum depth of water at low tide in the "cut" through the bar of the Mersey is maintained at 30 ft. On the St. Lawrence, works in hand are intended to give a minimum depth of 35 ft. from Montreal to the sea—a marvelous change from the minimum of 10 to 12 ft. formerly existing on that river during the greater part of the navigation season. On all sides there is and has been recognition of the need for ample depth of water.

VIII. MARGINS IN DIMENSIONS OF ENTRANCES.—When the foregoing particulars for locks, docks and approach channels are considered in the light of dimensions of ships given in Tables I. and II. it will be seen that the margins provided in most of the recent engineering works are not very great in regard to length and breadth, although they are expected to prove sufficient for many years to come, because of the commercial considerations above mentioned. To the lengths of ships tabulated must be added about 30 to 35 ft. in order to obtain the lengths "over all"; and in regard to breadths it is obvious that good working clearances in breadth are desirable for ease and safety of handling these enormous vessels when passing through dock entrances.

This is the more necessary because of the modern tendency to increased height and bulk of superstructures in which much of the passenger accommodation is situated. The effect of wind on the broadside in such cases is considerable and on that account, as well as the great effect which tidal currents may have on ships of enormous length, relatively wide entrances are needed in order to facilitate docking. As to draft of water, the figures given for merchant ships must be supplemented by about 2 ft. to insure sufficient depth of water under the keels for safe passage over the ground at low speeds. For warships, the deep load-drafts in vessels of recent construction are in many instances from 4 to 5 ft. greater than the so-called "normal" drafts given in Table II.; the displacement tonnages when fully laden require to be correspondingly increased. When warships have been damaged by accident or in action, so that their draft has been increased and their trim affected, serious difficulties must be experienced in docking them unless there is a good margin of depth over the sills as compared with the "normal" draft shown in Table II.

IX. HARBOR IMPROVEMENTS.—It is a fact worth noting that ships of the maximum dimensions now built or building are not easily accommodated or moved in the largest docks and harbors. The vessels are wonderfully handy, as all who have seen the Lusitania and Mauretania approach or leave the docks at New York, or the landing stage at Liverpool, will agree; but they necessarily require large spaces for their maneuvers because they are so long and heavy, and in the busy waters of their terminal ports caution is required.

It has been stated recently that the provision of suitable docks at New York for the latest transatlantic liners will involve an encroachment on the fairway of the Hudson River which may prove disadvantageous to the general traffic of the port. Whether or not this statement is well founded the general truth of the foregoing remark will be admitted. Ships of 900 to 1,000 ft. in length, weighing 40,000 to 50,000 tons when deep-laden are not easily dealt with, especially when moving on restricted spaces and in tideways, wherein other vessels are under way, and they themselves must necessarily move at low speeds. In many ports also the great drafts of water of the ships impose considerable restrictions on the water area which they can utilize with safety to themselves. Even in the terminal ports of the transatlantic steamers difficulties are necessarily experienced, and although they have been overcome so far, they must be accentuated by any further increase of size.

X. CONDITIONS AFFECTING WARSHIPS AND CARGO VESSELS.—For cargo steamers and warships no such fixed conditions or terminal ports exist. The former class are built to seek cargoes everywhere and to deliver them wherever desired. Consequently experience has led to the adoption of relatively moderate dimensions and draft of water, in order that their possible field of operations may be extended widely.

Warships are designed to operate from special bases, but they must find great advantage from being able to enter and utilize other harbors or sheltered waters where the depth of water is moderate. It is desirable also that they should be capable of proceeding to any place where an enemy can be found, and thus enlarge to the utmost their field of operations. Moderate draft of water is therefore an important feature of warship design; and the tendency in recent years to a considerable increase in the deep load-drafts of warships is, from this point of view, objectionable. As above stated the "sinkage" of modern warships (from normal to deep load-draft) is frequently 4 to 5 ft.; and although this fact may be ignored in statistical returns it must seriously affect the practical working range of action of the vessels in war-time.

In respect of draft of water, the United States Navy formerly favored shallowness—indeed insisted upon it—although naval architects did not fail to point out the penalizing influence of that restriction. It will be interesting to be told why this remarkable change of attitude has been made.

It is notorious that some of the most recent capital ships added to war-fleets cannot, when fully laden, find shelter in harbors which have been built primarily and at great cost to serve as naval bases, and they cannot be placed in many existing dry-docks, in case of injury in action, because of their considerable load-drafts. It will not be disputed that one essential factor in framing a shipbuilding program for any war-fleet should be the consideration of the harbor and docking accommodation which will be available, in case of war, for the reception and repair of the largest vessels.

For warships as well as for merchant ships, expenditure on ships and armaments must be considered concurrently with that on harbors and docks, and in every well-devised program the two things must be dealt with concurrently. This is a truism, no doubt; but past events prove that it may, none the less, be neglected in the excitement of a race to produce the "biggest warships" each carrying the greatest number of the heaviest guns.

XI. ADVANTAGES OF LARGE DIMENSIONS.—Enlarged dimensions, of course, enable certain ad-

vantages to be obtained, outside the fundamental gains of economy in sea-transport or increased speed. Among these advantages are:

(a) Maintenance of speed at sea in rough weather, and increased uniformity of service between terminal ports.

(b) Greater steadiness and good behavior in rough water and increased comfort for passengers, if naval architects are left free to utilize fully the greater size of ships. Not infrequently they do not enjoy such freedom, because the conditions laid down impose limitations on their choice of dimensions and proportions.

(c) Better and more spacious accommodation for larger numbers of passengers.

(d) The attraction which many passengers have toward the "biggest ships afloat."

A few remarks may be added respecting the first and second of these supplementary gains due to larger size in passenger steamships.

Maintenance of speed in rough seas and storms is obviously affected by the relative dimensions of ships and waves. Storm waves in the Atlantic Ocean and elsewhere attain certain maximum dimensions. The observations of Dr. Scoresby, Lieut. Paris, and others have enabled us to accumulate a great body of information respecting the sizes and speeds of ocean waves, and more than 30 years ago, I brought these facts together in the "Manual of Naval Architecture." Certain additions to our knowledge of wave-phenomena have been made since that date, but the main facts remain substantially as I stated them in 1877 for the information and guidance of naval architects.

Ocean waves have not grown in size because larger ships have been built; and obviously there must be an upper limit of size, beyond which, so far as maintenance of speed is concerned, further increase in the dimensions of ships will have little or no effect upon regularity of performance of service between terminal ports. I have previously recorded my opinion that this upper limit of size has been reached for the transatlantic service in the "Mauretania" and her sister ship, and I will now briefly state certain facts on which that opinion is based.

The "Mauretania" has averaged for a whole year, on 30 consecutive passages (15 voyages) westward and eastward, in all weathers and under varying and uncontrollable conditions of service, a mean speed of 25.5 knots. The highest mean speed going west was 26.06 knots; coming east it was 25.89 knots; the lowest mean speed was 24.92 knots in both directions. This regularity of performance has been repeated during service in two following years, the average mean speed being 25.25 knots and 25.1 knots, respectively. In the series of passages made between February and August this year the total number of revolutions of the screws during each passage varied only 2% above or below the number of revolutions per passage deduced from an average for all the passages. These figures may be left to speak for themselves. A closer approach to regularity of performance on the transatlantic service can hardly be realized whatever may be the sizes of the ships employed.

Experience proves also that in the Cunarders the limit of speed at which they can be safely driven in heavy seas is not fixed by their size, engine power, or general structural strength, but by considerations of the serious damage which might be done to fittings and navigational appliances as well as to the officers and crew employed in navigating the ships, and of the safety of passengers if the ships were driven at high speed against heavy seas. No prudent commanding officer is likely to incur unnecessary risks in these directions; and so there comes a time when the vessels are not driven at full speed against heavy seas but are slowed down until the weather moderates. This will always remain true whatever the sizes of ships may be.

In regard to steadiness in a seaway, long experience has shown that ships of less size may be more free from heavy rolling in a seaway than much larger ships, if the latter are endowed with greater stiffness and consequently move more quickly when rolling. Speaking on the basis of numerous personal observations made on ocean voyages, I can testify that this is the fact both for merchant ships and for warships. In recent years increase in the proportion of breadth to draft of water has tended to shorten periods of oscillation. No doubt in modern passenger steamers the lofty superstructures tend to raise the center of gravity and so to diminish stiffness and lengthen periods of oscillation. The increased breadth of ships has also tended to lessen the "effective wave-slope," and so to diminish rolling. Apart from detailed calculation, no exact knowledge can be reached respecting the probable behavior and period of oscillation for a new ship; but that fact in no way contradicts the general statement made above, that large dimensions are not necessary to secure moderate rolling and easy motion.

In modern warships of the largest types, as I pointed out in the paper read last year to this society, the periods of rolling oscillation are actually less than the corresponding periods for smaller ships which preceded them; and it is certain that, as a result, the larger ships must prove less steady gun-platforms than their predecessors under the influence of ocean storm waves, such as are frequently encountered.

XII. LARGER DIMENSIONS AND COMMERCIAL CONSIDERATIONS.—In view of the foregoing statements it becomes apparent that larger dimensions are not essential to good behavior at sea, and that increase in length and weight beyond the "Mauretania" is not necessary in order to secure maintenance of speed on long ocean passages. It would appear therefore that the main determining factor in regard to maximum dimensions for future mercantile vessels must be found on the commercial side and not on the technical. If ships cannot be made to pay dividends on the capital sums invested in them—after meeting working expenses and cost of upkeep, and making due allowance for insurance and depreciation—they are not likely to be built.

The first cost of transatlantic passenger steamers has been increased enormously during the last 40 years. In 1874, a 15-knot steamer cost $1,000,000; in 1889, a 20-knot steamer cost $1,875,000; in 1893, a 22-knot steamer cost about $2,750,000; in 1899 the "Oceanic," of 20.75 knots with relatively good cargo capacity, cost $3,500,000; four years later a 23-knot steamer of about the same dimensions as the "Oceanic" cost $4,000,000. For later ships, authoritative figures have not been published, but certain statements indicate approximately the sums which have been spent upon them. The British Government granted to the Cunard Co. a loan of $13,000,000 toward the construction of the "Lusitania" and "Mauretania," and it is understood that the actual cost of the two vessels exceeded that amount. The outlay on the "Olympic" has been put at about $7,500,000 by men who had exact knowledge of what she has cost. The Hamburg-American and Cunard steamships now building would, on this basis, represent an expenditure of about $8,750,000 per ship. There can be no doubt that experienced men who guide the policy of these three steamship companies have reached the conclusion that even such huge expenditure as these figures indicate will, on the whole, prove advantageous to the owners and lead to increased revenue.

It is not my purpose to attempt even the roughest estimate of earnings or working expenses for the new vessels. On the other hand, it may be well to call attention to certain facts and opinions which are already public property and which bear on the subject. In 1902 a committee appointed by the British Government to consider and report on the employment of mercantile cruisers and the subsidies proper to be paid for the services of such ships, expressed the opinion that commercial companies would require to be paid annual subsidies for swift steamships in order to make good "the loss which would be sustained in peace time for running such vessels." For ships having a sea-speed of 25 knots the committee considered that the annual subsidy ought to be 15% of the first cost; for 23-knot vessels, 8.6%; for 20-knot vessels, 2.6%. The essential point in this recommendation was that extremely fast vessels could not be worked without loss, and that if they were to be made available for use as auxiliary cruisers in war, annual subsidies should be paid. National sentiment was strongly in favor of recovering ownership of the swiftest ocean steamships for Great Britain; Parliament approved that action; an agreement was made with the Cunard Company to build the "Lusitania" and "Mauretania"; an annual subsidy of $750,000 was arranged; and the loan above-mentioned was granted at 2¾%, to be repaid in 20 years. Only the owners of these two vessels can know whether or not they have earned dividends and it is their concern alone. It is noteworthy, however, that no attempt has yet been made to surpass these vessels in speed, and that the five ships of greater size for which particulars are given in Table I. are intended to be slower than their predecessors. They may, in fact, be regarded as the latest developments of the "intermediate" type of transatlantic steamships, rather than as additions to the series of "express" passenger steamers in which very little cargo is carried, of which the Cunarders are the latest examples.

The essential characteristics of the "intermediate" type of steamships are moderate speed in proportion to length and displacement, and the association of large passenger accommodation with a considerable cargo capacity. Moderate speed, of course, permits of relatively moderate engine-power, lessens the coal-bill and engine-room expenses, makes less demands for space for engines, boilers and fuel, and leaves free for other uses a larger proportion of the internal capacity than in express steamers. All these differences obviously tend to increase net earnings in vessels of the intermediate type relatively to express steamers of equal size, but much higher speed; provided that passengers and cargo can be obtained. On the other hand, if cargoes are obtained which utilize the full dead-weight capacity of a very large steamer of the intermediate type, it may happen that the period of detention in port may be considerably in excess of that required for the passenger service and for recoaling. As a consequence there may be so considerable an increase in the time spent in port—during which the capital is unproductive—as will seriously diminish the net earnings. Every one agrees that for large and costly ships a quick "turn round" is of vital importance to commercial success and the shipment and discharge of large cargoes must interfere with that procedure.

It is not my purpose to attempt any detailed discussion of this branch of the subject, nor have I the experience which would enable me to do so. Speaking to naval architects, however, it may be permitted to make a brief statement which will illustrate the points last raised, and show the essential differences between the "Mauretania" and "Olympic." Let it be assumed that the two ships start at the same deep load-draft—34 ft. Allowing for differences in speed and engine-power the coal burnt for propulsion on a transatlantic passage by the "Olympic" at 21 knots would be about 70% of that required for propulsion by the "Mauretania" at 25 knots. For other purposes the daily coal consumption of the "Olympic" would rather exceed that of the "Mauretania" because of her larger size and greater number of passengers. The duration of the passage would be about 20% longer for the "Olympic" and on this basis the dead-weight cargo capacity of the "Olympic" at the load draft assumed for both ships would probably exceed that of the "Mauretania" (roughly) by 10,000 tons.

This is obviously a potential source of larger earnings, provided cargoes can be secured and dealt with in port without objectionably long detention. It may be doubted whether this full cargo capacity would be frequently utilized, even coming eastward, and going westward there would be no prospect of its utilization under the conditions of actual transatlantic service. If not so utilized the vessel could of course be worked at lighter draft, or could carry coal from England for the voyage out and home, or be otherwise dealt with. On the other hand, the under-water form would always remain that which was selected as appropriate to the carriage of a large dead-weight; and if the provision made for cargo had been less it would have been possible to produce a vessel of smaller displacement and less cost having the same speed, with reduced working expenses and equal passenger accommodation. These remarks are made in no spirit of criticism. Those who were responsible for the construction of the "Olympic" are undoubtedly masters of all details of shipping and ship management, while I am only an outsider in mercantile affairs and necessarily regard the problem from the point of view of a naval architect. Even that point of view should not be ignored, however, and it will have an influence on the future developments of mercantile steamships.

XIII. HUGE WARSHIPS IN TIME OF WAR.—For warships, other considerations than those of first cost and cost of maintenance must determine the maximum dimensions which should be adopted. Their case is, therefore, distinct from that of merchant ships and must be considered on its merits. Advocates of further increase in size and cost of warships take a different view and argue that because a few mercantile steamships have reached dimensions far in excess of those attained by warships, therefore it is reasonable to follow a similar course in warship construction. This argument has already been dealt with indirectly in Section X. The comparatively few merchant steamers of very large dimensions now in existence have been built for special service between known terminal ports, whereat proper accommodation for them has been provided. Their employment consequently differs radically in character from that of warships which are intended to seek out and find an enemy wherever he may be. In

TABLE I.—GROWTH IN DIMENSIONS OF TRANSATLANTIC STEAMSHIPS.

Line.	Name.	Date.	Length, feet.	Breadth, ft., in.	Depth, ft., in.	Gross tonnage.	Load draft, ft. in.	Load displacem't, tons.	HP.	Sea-speed, knots.
Cunard	"Persia"	1856	360	45—0	31—5	3,300	23—0	6,000	[illegible]	13
White Star	"Germanic"	1874	455	45—0	36—0	5,000	23—0	8,500	[illegible]	16
Cunard	"Oregon"	1883	500	54—0	40—6	6,900	23—0	10,500	[illegible]	18
White Star	"Teutonic"	1889	565	57—6	42—0	9,700	23—0	13,000	[illegible]	20
Cunard	"Campania"	1893	600	65—0	41—6	12,500	27—6	20,000	[illegible]	22
White Star	"Oceanic"	1899	685	68—5	49—0	17,274	30—6	26,400	[illegible]	20.75
North German Lloyd	"Kaiser Wilhelm II"	1903	678	72—0	52—6	19,360	29—0	26,000	[illegible]	23.5
Cunard	"Mauretania"	1907	760	88—0	60—5	31,938	34—0	39,000	[illegible]	25.5
White Star	"Cedric"	1903	681	75—3	44—1	21,000	32—0	32,000	[illegible]	16.5
White Star	"Adriatic"	1906	709	75—6	52—6	24,540	34—0	36,000	[illegible]	17
White Star	"Olympic"	1911	850	92—0	64—3	45,000	34—0	50,000	[illegible]	21
Hamburg-American	"Imperator"	Building	830	96—0	64—0	about	34—0	to	[illegible]	22
Cunard	"Aquitania"	Building	885	95—6	.....	50,000	34—0	55,000	[illegible]	23

order to secure success, therefore, each navy needs a considerable number of ships, and the draft of water of individual vessels ought to be moderate in order that their field of possible operation should be large.

Warships are also exposed to special risks, to which there is nothing corresponding in the services for which great mercantile steamers are constructed; and as a consequence it is essential to provide for considerable numbers as well as for individual power in the constitution of each fleet. It is admittedly a correct definition of the problems involved in the arrangement of an "establishment" for any navy, to say that it must rest on a definite plan of campaign, the fulfilment of which requires the construction of a certain number of ships of various types suitable for various services, and ranging from capital ships—forming units in squadrons and fleets—down to the smaller classes of armed vessels and the fleet auxiliaries. For each fleet of capital ships it is necessary to arrive at a decision as to the best distribution of the total sums to be expended on construction and subsequent maintenance; and in reaching such a decision regard must be had to the special risks incidental to modern naval war, as well as to the necessities of naval operations which must demand the capability of either concentrating or distributing the force as the varying conditions of a campaign may require. Problems such as these naturally, indeed necessarily, give rise to different solutions, and there is room for various opinions as to the best possible arrangements in proportion to total expenditure. My personal opinions on the subject were expressed in the paper on "Armaments of Battleships" last year.* It may assist the present discussion if they are briefly summarized.

(a) Multiplication of the heavy-gun positions in capital ships, and of the number of such guns carried by individual ships, has necessarily involved increase of lengths and displacements.

(b) Concurrently with this alteration of armament there has been an increase in speed and fuel supply: this has involved further increase of size.

(c) Modern capital ships—with heavy-gun armaments and great weights of armor placed high above water—must be endowed with considerable initial stability in order to possess a reasonable range of stability under ordinary peace conditions. Hence they have been made very broad in relation to their drafts of water—even after allowance is made for the increase in draft (deep laden)—as compared with their predecessors.

(d) Their moderate range of stability (when intact) gives to these ships a less margin of safety when injured in action by gun-fire; and, in many instances, the distribution of the armor is of a character that adds to this risk, because it leaves without protection large areas of the sides which are reckoned as water-excluding in calculations of stability, although they can be rapidly riddled and destroyed by shell-fire with high explosives. In later designs the areas which are armor-protected have been considerably increased; but the addition to the weight of armor placed high above the water-line has necessarily been accompanied by a rise in the position of the center of gravity of the ships. The breadths have been still further increased in proportion to the drafts, and even then the range of stability in the intact condition is very moderate.

(e) Modern warships, notwithstanding their greater size, are not, and cannot be as steady gun-platforms as their predecessors; because their great initial stability causes them to have relatively short periods of oscillation. As a consequence they are more likely to be set rolling by ordinary conditions at sea. Experience has shown them to be less steady in a seaway than ships of earlier date and smaller size. Some of these ships are so large in relation to the available dry-docks that their bilge keels are either very shallow or non-existent at the midship portions of the length; and as a consequence the check upon rolling is greatly reduced.

[*Engineering News, Dec. 15, 1910.]

(f) The development of under-water attacks proceeds rapidly. Torpedoes are now larger, have greater charges, are much faster and can be used at much longer ranges. Submarine mines have been used with great effect in actual warfare, and will be used in future with greater effect. Submarines have been developed, and are now being made of dimensions, speed, and radius of action which probably enable them to act as auxiliaries to fleets over considerable areas of operation. Advocates of very large dimensions in warships admit that one successful under-water attack will probably put the largest warship out of action. It cannot be questioned that the increase in length and speed of recent ships will necessitate an increase in the intervals between successive ships in the line of battle, and the danger of successful under-water attack will be increased because both individual ships and the line of battle formed by a certain number of ships must be made longer.

(g) In view of the foregoing considerations, it appears to be desirable to put a limit upon the size and cost of individual warships, and the concentration of so many guns in a single ship; because a single successful blow may bring about a serious proportionate loss to a fleet by one ship being put out of action. Moreover, the withdrawal of a single ship from a fleet, for temporary employment on detached service, would involve a serious loss of power which, with more numerous vessels, would be avoided.

(h) Special dangers must be incurred by the multiplication of heavy guns and of magazines placed below them. Some of these magazines are necessarily in the neighborhood of boiler-spaces or bunkers, where high temperatures are unavoidable. No doubt the dangers are lessened by fitting appliances for keeping magazines cool and by other devices; but although lessened they are not absolutely overcome and the risk of explosion—as sad experience proves—remains. The loss of the "Liberté," which is universally deplored, following upon a previous accident to the "Jena," demonstrate the possibility of possible and sudden destruction in this fashion of the largest ships and furnishes a fresh argument against "putting too many eggs in one basket."

My personal conviction, based upon long-continued study of the problem, is that the wiser course in warship building would be found in a return to more moderate dimensions and a reduced unit-cost for capital ships. Experience has established the fact that, without having resort to the extreme dimensions which have recently found favor, it is possible to produce capital ships which shall be powerfully armed, well protected, steady gun-platforms, capable of fighting their guns in all weathers when actions could take place, and able to maintain their speed in rough water.

The value of high speed in capital ships has been much discussed, but it really opens up a separate field into which it would be undesirable to enter now.

Suffice it to say that with equal speed a reduction in the number of heavy guns carried in a single ship such as I advocated last year, would enable considerable reductions to be made in size and cost; and that, for a given total expenditure on the first cost of a fleet or squadron, a more formidable and flexible force could, in my judgment, be obtained, with greatly reduced risks from either gun fire, under-water attacks or magazine explosions. It would probably be true, that the more numerous fleet would cost more for manning and maintenance, but the price which would have to be paid in this direction would be well earned by advantages in other respects; and above all by a greater prospect of success in the day of battle.

The Manufacture of Glass in the United States in 1909 is reported in a special bulletin of the Bureau of the Census containing comparisons of general figures for 1904 and 1909. The details of growth are shown in the accompanying table. The item "miscellaneous expenses" shown includes rents, taxes, contract items and office expenses, etc., not classified elsewhere:

PRODUCTION OF GLASS IN 1909: U. S. CENSUS BUREAU REPORT.

	1909.	Per ct. of increase 1904-'09.
No. of establishments	363	[illegible]9
Capital	$129,288,000	45
Cost of materials used	$32,119,000	22
Salaries	$4,393,000	27
Wages	$39,300,000	5
Miscellaneous expenses	$8,961,000	52
Value of products	$92,095,000	16
Value added by manufacture	$59,976,000	12
No. of salaried officials and clerks	3,575	19
Average No. wage earners	68,911	8
Primary horsepower	128,532	40
Products by kind and quantity:		
Building glass, square feet:		
Window glass, 50-ft. boxes	6,921,611	43
Plate, total cast	60,105,694	73
Polished	47,370,254	74
Rough, made for sale	205,690	1,057
Cathedral	7,405,980	12
Skylight	15,409,966	1
Pressed and blown (dozens):		
Chimneys	6,652,967	[illegible]5
Globes and other electrical goods	11,738,798	517
Tableware, etc.	66,394,529	173
Other	5,718,553	33
Bottles and jars	12,428,781	[illegible]19

[illegible]Denotes decrease.

Diesel Engines for a German Battleship.—At the Nuremberg works a Diesel engine of six cylinders, to develop 12,000 HP., has been designed, the intention being to install it in a large German battleship. The engine has been designed so that each set of three cylinders is self-contained and forms a complete machine capable of working independently; the first set has been constructed and has during the past week or two been running in the shops. So far as can be shown by so short an experience, the results have been satisfactory, and the favorable fact has been deduced that with a six-cylinder engine, instead of the power developed being 12,000 HP., some 16,000 HP. will be obtained with ease—i. e. over 2,500 HP. per cylinder. This engine is of the two-cycle double acting type of the usual Nuremberg construction. It is thus similar to those of 1,500 HP. and 1,000 HP., which have been built for the Hamburg-American vessel and the Woermann liner.

Another of the chief firms of Diesel engine manufacturers, Messrs. Sulzer Brothers, of Winterthur, Switzerland, have definitely decided to adhere to the single-acting principle for all Diesel engines. In these works a two-cycle four-cylinder stationary engine of 2,400 B. HP. has completed its trials, while a single-cylinder marine engine of 2,000 HP. is now being constructed, also single-acting; all the castings have been made and the engine is at present in course of erection. It will be an entirely independent reversible engine, and will represent the largest power in one cylinder which has yet been built to work on the single-acting principle.

After five years' work on the subject Messrs. Sulzer have now completed a locomotive which is driven by a Diesel engine, and trials are to be begun very shortly. Perhaps in no application of the Diesel motor are the difficulties encountered so great, or the possibilities of economy so high, as in its employment for driving locomotives, and the results of these trials will be watched with great interest.—"London Times Engineering Supplement," Oct. 25.

TABLE II.—GROWTH IN DIMENSIONS OF ARMORED WARSHIPS.

Navy	Name.	Date of order.	Length, ft.	Width, feet.	Load-draft, ft., in.	Load-displacem't, tons.	HP.	Trial speed, knots.
British	"Warrior"	1859	380	58	26—0	9,000	5,500	14.4
British	"Bulwark"	1899	400	75	26—9	15,000	15,000	18
United States	"Maine"	1898	388	72½	25—6	13,500	12,000	18
German	"Wittelsbach"	1899	394	68¾	25—0	11,900	15,000	18
French	"Suffren"	1899	410	70	27—6	12,700	18,500	18
British	"Lion"	1910	660	88½	28—0	26,400	70,000	28
United States	"Wyoming"	1909	554	93½	28—6	26,000	28,000	20.5
German	"Moltke"	1908	610	96¾	27—0	23,000	50,000	25.5
French	"Jean Bart"	1910	541	88½	29—6	23,100	23,000	20
Argentine	"Rivadavia"	1910	585	96	27—6	27,500	32,000	22.5

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Mr. Lindenthal on the Quebec Bridge Competition.

It is seldom that we have the privilege of presenting to our readers a paper of such great interest to the engineering profession as a whole as the contribution by Mr. Gustav Lindenthal on the Quebec Bridge Competition appearing in this issue. As our readers know, this was the most important international competition for the design of a great engineering structure which has ever been held. Properly conducted, and with the results properly made public, it ought to have added greatly to the profession's knowledge of the art of long-span bridge construction.

All we have ever been able to obtain for publication, however, has been the mere skeleton designs which were offered, with brief general description. Critical expert analysis of the various designs submitted and exposition of the problems to be met in the design has nowhere appeared.

Mr. Lindenthal's analysis of the chief features of the Quebec problem leads him to frank condemnation of the way in which the competition was conducted, and of the result of the competition. He bases all his criticisms on definitely stated reasons, and his remarks are therefore the more valuable. It may be objected that Mr. Lindenthal was one of the participants in the competition and is therefore biased in his views; but it will be apparent, on the other hand, that no one who had not given such thorough study to the problem as was necessary for preparing a design could furnish such a searching expert analysis as Mr. Lindenthal gives.

More than this, it will be generally agreed, we are sure, that in the entire engineering profession of this or any other country there is hardly an engineer who is so competent by experience and ability to deal with the problem of long-span bridge design as Mr. Lindenthal. Even those who may dissent from some of his criticisms will agree that his standing as an expert in this field is such that whatever he has to say deserves careful attention by bridge engineers everywhere.

Mr. Lindenthal prefaces his discussion of the recent competition in designs for the Quebec Bridge with some comments on the unfortunate past history of the enterprise. His reference to the meager allowance for engineering services in connection with the construction of the first bridge deserves a word of especial emphasis.

We have had occasion recently, in connection with another disaster to an engineering structure, to declare that the public which employs engineers seeks to economize by buying engineering at the lowest possible price and buying just as little of it as possible. That this policy may result in great disasters, both Quebec and Austin are object lessons to prove; but it is also true that apart from the question of safety, niggardly economy in engineering expenses often causes a waste many times as great as the money saved in salaries. Thorough engineering study of plans for a structure, for example, will often reveal ways in which large economies can be made. Work which has to be planned under stress of great haste or with insufficient force to work out detailed plans and specifications is apt to be expensive work to carry out.

The same principle holds in many fields of engineering. Many millions of dollars have been spent in railway construction which might have been saved had greater time been given to the locating surveys and a higher grade of talent secured for the locating parties. Many cities have economized in engineering work on sewer construction by building up a system piece-meal without any well digested plan of construction, such as a competent engineer might have furnished. Eventually a complete plan has to be prepared and the system reconstructed at great expense. Examples might be multiplied by the dozen; but for the most striking example we may turn to the Quebec Bridge itself. In a second article on this work to appear in a following issue of this journal, Mr. Lindenthal shows that the Canadian Government will in the end have spent about $18,000,000 to build the St. Lawrence River Bridge, when a bridge of greater capacity with a large margin of strength could have been constructed inside of $10,000,000.

When an engineer is really able "to make a dollar earn the most interest," purchase of his services is an investment paying greater return than any other of which we know. And while it is generally unsafe to choose investments which promise a high rate of return, the rule is reversed in this case and the unsafe thing is to economize in engineering work.

The Most Powerful Engine in the World.

We briefly noted last week the placing in service by the New York Edison Co., at its Waterside Station, of the most powerful engine ever built—a Curtis steam turbine with generator superposed upon it constructed by the General Electric Co., the unit being capable of an output of 20,000 kilowatts or 30,000 horsepower in round numbers. The reception held by the officers of the company to celebrate the formal starting of this monster machine was well justified by its importance as an advance in engineering practice, as well as by the spectacular contrast between the new turbine and the battery of reciprocating engines which it replaced.

Ranged along one side of the company's Waterside Station No. 1 is a row of seven vertical reciprocating 5,000-HP. engines with direct-connected generators. Along the other side of the station Curtis turbines are being erected in place of the engines which formerly stood there. It is not so many years ago that a reciprocating engine of 5,000-HP. was considered as a wonderful feat of engineering; in fact, until the advent of the modern electric power station the stationary steam engine was seldom built of very large size. One had to go to marine service to find the steam engines of largest power.

The 5,000-HP. engines in the Edison station are huge vertical machines, occupying more than twice as great a height in the station as the new 3,000-HP. turbine, and each single one of them occupies as much floor space.

In the presence of the assembled guests, steam was turned on to the turbine until it was brought up to speed and the generator was put in step with the others in the station. Then it was turned on to the line and the shutting down of the reciprocating engines began. On one after another of these huge machines the throttle was closed and it gradually slowed down to rest until the whole seven were standing still and the entire load which they had formerly carried was shifted to the new turbine.

The advantage of the new machine is not especially in fuel economy, its steam consumption per horsepower being approximately the same as that of the reciprocating engines which it displaces. Its advantage lies first in the small floor space which it takes up and second in the enormous reduction which it makes possible in the cost of attendance. It required a small army of engine-runners, oilers, etc., to attend the huge reciprocating engines with their many moving parts. Constant vigilance was necessary to guard against hot bearings or other difficulties. There was a great range of piping to be cared for and a correspondingly large opportunity for leaks and breaks. With the turbine, the attendance is reduced to the smallest proportions. The simplicity of the machine makes automatic lubrication a comparatively certain matter.

It is true, of course, that there are few power stations as yet large enough, to permit the running of a power unit of such enormous size. Its installation well illustrates, however, the possibilities in electric power generation at the present day. It seems reasonable to believe that with machines which involve such small expense for attendance and maintenance the cost of electric power may be reduced materially below the figures which have hitherto been accepted as a minimum.

An Authoritative Opinion on Increase in the Size of Ships.

A question which is all the time coming up in civil engineering works connected with water transportation is the probable future dimensions of ships. Every one will recall the active discussion over this question when the dimensions of the Panama Canal were fixed, and it is now prominent in connection with the subject of pier construction in New York Harbor.

Under these circumstances, the paper on this subject which we print in this issue by Sir William White deserves more than passing notice. It would be difficult to name an engineer anywhere in the world whose opinion on this subject carries greater weight of authority. As the designer of the fastest and, up to a few months ago, the largest merchant vessels afloat and as the former head of construction of the British Navy, Sir William speaks with a broader knowledge of the subject than almost any engineer anywhere can possess. In this paper, as in the previous one from his pen which we published in our issue of Oct. 6, 1910, Sir William emphasizes the fact that the ocean carrying trade of the world is still carried on by vessels of moderate size, and so far as can now be seen is likely to be for many years to come.

Of course, there has been a steady increase in the average size of vessels during the past 40 years since steam established its supremacy on the ocean; but this increase is by no means so great as the casual investigator, who judges by the huge transatlantic liners which bulk so prominently in the public eye, is apt to conclude.

It is well to emphasize that the reason and the sole reason for increase in the size of merchant vessels is the commercial one. The only reason for building and operating large ships is because they return greater profit to the owner than small ships. Experience has shown that very large (and very fast) vessels cost a great deal more to construct per ton of carrying capacity and, unless they can be continuously loaded to their capacity without too great delays in port, they also cost more to operate.

The rapid increase in the maximum size of vessels on the Great Lakes has been made possible through the enormous volume of traffic furnished by the iron ore trade, in the first place, and by the achievements in rapid loading and

unloading by mechanical appliances, in the second place. For ordinary package freight on the Great Lakes, the vessel that pays best is a ship which is diminutive compared with the huge ore carriers.

An instructive object-lesson as to one of the drawbacks to vessels of enormous size is furnished by the huge trans-Pacific steamships, the "Minnesota" and "Dakota," built half a dozen years ago for the Great Northern Ry. The "Dakota" was wrecked on the Japanese coast after a very short term of service, and cable dispatches on Nov. 11 reported the grounding of the "Minnesota" in Japanese waters, with what resulting damage is not yet reported. With every increase in the draft of vessels comes a certain increase in the risk of injury or loss by grounding.

Of equal interest with Sir William's opinion as to the size of merchant vessels is his pronounced stand in favor of a reaction in naval architecture and a return to smaller size units for cruisers and battleships. During the past five years there seems to have been a perfect craze among the navies of the world to vie with each other in the production of "Dreadnoughts" and "Super-dreadnoughts" until it has become only too evident that the enormous cost of these huge vessels, combined with their short, effective life, would soon set a limit to further increases in size. The distinguished author of the paper in question takes an emphatic stand in favor of battleships of moderate size instead of the huge floating batteries on which public attention has of late been concentrated. As he points out, the vulnerability of a vessel is by no means increased in proportion to its size, and since in even the most wealthy nations the amount of naval construction is determined by available funds, there is much to be said for the policy of putting not too many eggs into one basket.

Storage Reservoirs for River Regulation in Western Pennsylvania.

The active discussion over the merits and demerits of storage reservoirs for river regulation, which was carried on two or three years ago, is likely to be revived by the announcement that the Pittsburgh Flood Commission has rendered a unanimous report in favor of storage reservoirs on the headwaters of the Allegheny and Monongahela Rivers.

The first chapter of the forthcoming report of the Flood Commission was printed on page 578 of our last issue. Those who read it carefully were doubtless impressed with the sweeping character of the recommendation in favor of reservoirs and by the weight of engineering authority behind the recommendation.

The Flood Commission's decision is the more interesting and important because, if we are rightly informed, the Commission began its work with more or less prejudice against the reservoir system, and inclined toward some system of diking as the best solution. The decision in favor of storage reservoirs comes as the result of thorough investigations and surveys, which have been in progress for nearly three years. On the basis of these surveys, the cost of making Pittsburgh secure against future floods is set at $20,000,000. As the Commission points out, the benefit from the reservoir construction will have to do not alone with flood protection but with the maintenance of flow in the rivers during long seasons of drought. We do not know whether any estimate has ever been made of the cost to Pittsburgh's industrial district of the foul and acid water existing in the Monongahela pool when the river is at its lowest stages, but we should suppose that it would amount to a very large sum. An ample flow in the Monongahela during this low-water season would greatly reduce this damage and might go far to pay the interest in the investment in the proposed reservoir system.

So far as navigation alone is concerned, the argument for reservoirs has perhaps rested on rather a doubtful basis, but the other benefits which may accrue from a well planned reservoir system under the conditions existing at Pittsburgh should furnish a strong argument for its undertaking. The appearance of the Flood Commission's complete report will be awaited with interest by the profession.

Speaking Up for the Engineering Profession.

In passing a resolution asking that Governor Dix of New York select an engineer for appointment when the next vacancy occurs in the Public Service Commission of New York City, the Brooklyn Engineers' Club has set an example which other engineering societies might well follow. It is eminently desirable that administrative commissions and offices which have to plan, construct or operate engineering works should be filled with engineers—men whose training and experience enables them to judge wisely in dealing with problems of this kind.

That the appointments made show nearly always an entire disregard of this requirement, and that lawyers, political leaders or "business men" are the men usually selected for appointment, is known and deplored by engineers everywhere. In order to secure efficient government it is necessary to change these conditions, and it is the duty of the profession to work for such a change.

It has often enough been remarked that engineers' societies are far less active than other professional organizations in taking the lead where questions of interest to the public are to be solved. The only explanation for this is conservatism, the only reason, lack of aggressive courage. Engineers are notoriously over-modest; they hesitate to "speak up" even though the interests of the profession are at stake. Let their professional organizations recognize their duty to exert their influence in public matters where engineering is involved and some progress may be secured toward intelligent and economical administration of public works.

An Offer of Free Highway Bridge Engineering Work By a Federal Bureau.

The Office of Public Roads of the United States Department of Agriculture has issued a Bulletin, entitled "Highway Bridges and Culverts," in which it offers to do the engineering work free of charge in connection with the construction of any highway bridge anywhere in the United States. The local authorities have only to make application and agree to furnish meals, lodging and livery teams to the engineer assigned to the work.

"The salaries and traveling expenses of engineers to and from the town where the work is to be done will be paid by the Office of Public Roads. The engineer furnished will advise what type of structure should be built, will prepare free of charge such plans and specifications as are required, and if the conditions require an engineer inspector during construction, such inspector will be assigned, free of charge."

This announcement is of great importance, it seems to us, to the engineering profession. What possible chance has a bridge engineer to earn a living by the independent practice of his profession, if the United States Government steps in to compete with him and offers to do his work gratis? And if the Government undertakes to do bridge engineering work free, why not other kinds of engineering work? Why not free sewerage plans for cities and towns as well as free bridge plans? Why may not the Government furnish engineers gratis to build systems of water supply, electric lighting and power plants, public buildings for towns and cities?

Certainly, if the Government steps in to compete with the individual engineers who are now struggling to make a living by independent practice, they may as well give up at once. What chance have they against such a competition? And when these engineers retire from the field, the Government will be obliged to continue what it has begun. There would very soon be no independent engineers left to which towns and cities could turn for advice.

It seems to us that this matter is of vital importance to every member of the engineering profession. Lest the reader may think we are overstating the case we proceed now to quote directly from the Bulletin. Its [illegible] page reads as follows:

Office of Public Roads.

BULLETIN No. 30.

LOGAN WALLER PAGE, [illegible]

HIGHWAY BRIDGES AND CULVERTS

BY

CHARLES H. HOYT, C. E.,

Superintendent of Construction, in charge of Bridge Engineering, Office of Public Roads.

AND

WILLIAM H. BURR, C. E.,

Professor of Civil Engineering, Columbia University; Consulting Engineer, Office of Public Roads.

The matter in the bulletin is popular rather than technical. The introduction, for example, contains such information as that "When Washington crossed the Delaware with his army there were no bridges over that river," and, "Nature has provided this country with at least nine natural bridges."

Under "Design," much stress is laid on the importance of securing engineering advice in bridge construction and it is recommended that as the first step in any bridge construction "the services of a capable bridge engineer should be secured." The pamphlet then proceeds with a brief discussion of foundation, bridge location, various types of concrete, masonry and steel structures, all as stated by Mr. Page in the preface "rather a general treatment of the subject, which will be taken up in greater detail in subsequent publications." At the close of the book comes the offer of free engineering work, as follows:

A new division has been organized in this office, to be known as that of "Highway Culvert and Bridge Engineering." The duties of this division will be to confer with local officials, upon their request, concerning this class of work, to make inspections and test foundations for bridges and culverts, to recommend such types of construction as will be practical for their locations, and to give such other information and assistance as may be practical in the individual case, such as making location surveys and preparing preliminary plans, forms of contract, specifications and estimates.

Just what this means is explained in greater detail in the blank form to be used in applying for an engineer, which we also reprint in full:

FORM TO BE USED IN MAKING APPLICATION FOR BRIDGE ENGINEER.

Office of.....County of.....
P. O. Address..... Date.....
To the Director, Office of Public Roads, Washington, D. C.

Sir: Application is hereby made for the detail of a bridge engineer to confer with the undersigned and give advice concerning plans for and construction of proposed bridges and culverts in this (town, County or State).....

Bridges.

No.
1. No. bridges proposed..... Approximate length of each.....
2. Approximate normal depth of water in stream.....
3. Kind of bridges desired (concrete or steel).....
4. Character of natural foundation.....

Culverts.

5. No. culverts proposed..... Approximate span of each.....
6. Character of natural foundation.....
7. What funds are available for proposed work.....
8. When is engineer desired and why.....

We will furnish, or cause to be furnished, transportation and assistance necessary to enable the bridge engineer of the United States Office of Public Roads to make an inspection and get necessary measurements of locations for proposed bridges and culverts. We will also provide subsistence for such engineer while he shall be engaged upon this work.

Signature of local officials having legal control over proposed work.

.....

.....

Explanation of Application for Bridge Engineer.

The information called for in this application is approximate only and intended to give some general idea of the present conditions and magnitude of the proposed work.

The salaries and traveling expenses of engineers to and from the place of assignment will be paid by the Office of Public Roads. The officials making this application must furnish means and lodging for the engineer, and such livery or other

transportation as he may need to execute his work expeditiously.

After such examination has been made, the engineer will recommend such type of construction as he considers practical and economical. If such recommendations are approved, the engineer will prepare, free of charge, such plans and specifications as are required to complete the work. Where conditions require and warrant the assignment of an engineer inspector during construction, such inspector will be assigned, free of charge, except for meals and lodging, while engaged upon such bridge or culvert construction.

By "natural foundation" the meaning intended is the nature of the material upon which the abutments or piers will rest, such as sand, clay, quicksand, mud, or rock.

It is important that all construction work be done thoroughly and well. Where the work is of such magnitude that this office deems that an engineering inspector is necessary, plans may be withheld until arrangements can be made to assign such an inspector.

It will be noticed that there is no limitation whatever in the above offer. So far as anything on the circular appears, the Office is prepared to spend two or three hundred dollars on the time and travelling expenses of an engineer to construct a bridge costing, all told, a thousand dollars or even a smaller sum. Perhaps it may be said that what the circular really means is that engineers will be furnished for small bridges and culverts, on which engineers in private practice are very seldom employed. It would be enormously expensive, however, to send engineers long distances to take charge of work on such small structures. Further, there is no upper limit set as to the size of structure, which the Office will undertake. Why should not a city proposing to build a steel or concrete bridge at a cost of a hundred thousand or a million dollars, take advantage of this free offer?

Suppose the Office were to be taken at its word. Suppose it were really to be called on to undertake gratis the engineering work on highway bridges throughout the United States. Considering the heavy traveling expenses involved, and the large proportion of small size work, the expense to the Government would not be less than 15% of the entire cost of construction, and probably would be very much more. This would mean an annual expenditure by the Office running into millions of dollars.

Ought the Federal Government to undertake such an expenditure? Ought the highway bridge construction work of the whole United States to be all concentrated and directed from Washington? If any one holds such an idea the burden of proof is upon him to convince the public.

Our readers are aware that Engineering News has been outspoken in its support of such work by the Federal Government as it has been found necessary for it to undertake for the general welfare. We are equally outspoken in opposition to any unnecessary centralization in Governmental functions. One of the greatest advantages of our dual State and Federal system is that it permits local matters to be handled by local authorities. Even in a comparatively small country like Great Britain, the centralization of all control over local matters in the National Government is realized by her ablest statesmen to be a serious burden in many respects. That it has become necessary to greatly enlarge the functions of our Federal Government is everywhere recognized; but this is one of the strongest arguments why such matters as *are* purely local and do not affect interstate relations should be left for each state to deal with as it sees fit.

The several states can each deal with their own highway problems far better and more economically than they can be dealt with by the National Government. The latter can usefully carry on such investigations and experiments as shall be serviceable in connection with highway construction anywhere; but when it proceeds to take charge of the actual work of building highways or bridges it is undertaking responsibilities which properly belong to the states themselves.

Nor is it an argument for such an enlargement of Federal powers that the states are, many of them, neglecting this work. Few states have attempted to supervise factory construction outside of muncipalities having building codes, for example, but this does not justify the Federal Government in assuming such authority.

It is true that in several states, where highway construction has been undertaken by the state on a considerable scale, the state authorities have also taken control of highway bridge work. This would naturally happen on roads built with state funds and the services of the state highway department have also been made available to towns and counties building bridges on other than state roads.

The preparation and free distribution of standard plans for culverts and small concrete or steel girder bridges has also been undertaken by state highway bureaus; and in a few instances, we believe, larger bridges have been built under their direction. We know of no state, however, whose highway department or state engineer's office has made any such broad and sweeping offer of free engineering work for local authorities as that which we have quoted above.

It is an open question, and one deserving fair discussion whether all highway bridge engineering outside incorporated cities ought to be carried on by a state engineering organization, so that the bridge engineer engaged in private practice would be forced to go out of business. Probably if state engineering departments were organized on an ideal basis, with competent and well-paid engineers in charge of all work, free to follow sound professional standards and free from political pressure, the answer would have to be in the affirmative. But until the public becomes wise enough to insist on the permanent establishment of such high-class engineering organizations, we are very doubtful as to the public benefit to result from wiping out the independent bridge engineer by having the state furnish bridge engineering gratis.

Whether or not highway bridge work in each state ought to be concentrated under one organization may be open to question; but it is difficult to imagine any sound argument in favor of concentration of all the highway bridge work in the United States. The best experts are now agreed that we have gone too far during the past decade in concentration in all our industrial work. Economy is now being sought by decentralization in the great industrial and railway organizations. The public is awakening anew to the advantages of free competition, to the importance of keeping a door open to originality, initiative and enterprise. There is no reason why bridge engineering should be turned over to the Government as a monopoly. The achievements of American engineers on bridge design and construction would never have been recorded under any central bureaucratic organization.

If the engineers of the country generally agree with us that the offer of a Federal Bureau to do free engineering work constitutes unfair competition with the practice of the independent engineer, we know of no reason why they should not, individually and through their professional organizations, protest to the Bureau in question and to their representatives in Congress. Surely any other profession would be prompt to utter protest under like treatment. Suppose some Federal bureau at Washington should offer to furnish without charge architects to undertake the construction of any public building for a town or city. The Chapters of the American Institute of Architects all over the country would be heard from in no uncertain terms. The chances are that next year's appropriation for that bureau would be missing.

Or suppose the Attorney-General's office were to offer to furnish free legal counsel to towns and cities throughout the country. Would not the attorney responsible for such a proposal meet condemnation at the hands of his professional brethren for infringement of their code of ethics?

Yet any such action as suggested would be far less hurtful to architects or to lawyers generally, for the bulk of the work in each of these professions is done for private clients. The work of the bridge engineer, however, is either for railway companies or for highway authorities. If the Government takes away the latter work, ruin stares him in the face.

Finally let us say that we shall look with confidence for the prompt withdrawal of this offer and the official disbandment of this new "Bureau of Highway Bridge Engineering." Certainly, if those whose names appear in connection with it have any regard for professional ethics or desire to retain their standing with their professional brethren, they will be prompt to withdraw from their present position.

It will be noted that one of the engineers, whose name appears in the Bulletin, holds the chair of engineering in a prominent university. What incentive have the students of engineering in that institution or in any other institution to continue their work and seek entrance to the profession if the best prospect held out to them is employment in a Government bureau? Neither Federal nor State Governments have been liberal enough in their recognition of engineering talent to make such a career attractive to an ambitious and enterprising young man.

LETTERS TO THE EDITOR.

Practice in Branding Cement.

Sir: In your issue of Oct. 12, p. 444, you have an article headed "Trust Methods in Selling Cement," in which comment is made on the fact that since the formation of the Canada Cement Co., all of the cement shipped from its various mills goes out under one label, namely, "Canada," with no other distinguishing mark whereby the consumer may know which of the heretofore well-known brands he is buying, and stating that in consequence, there is a marked disposition among cement users to ascribe any troubles with concrete to uncertainty regarding the source of the cement.

With part of your statement I quite agree. I cannot agree, however, with that part in which you state that there is a marked disposition among cement users to ascribe any troubles with concrete to uncertainty regarding the source of the cement. There is a marked disposition among users of cement to ascribe any trouble with concrete to the cement used, for there is, always has been, and probably always will be, this disposition among cement users.

It is not true, however, that anyone has to use any cement made by the Canada Cement Co. without a thorough knowledge of the mill from which the cement was shipped, because any customer has at any time the privilege of ordering cement from any one or more of the company's eleven mills, and if necessary can even procure small bins at any of its factories, where cement can be tested and kept under seal until shipped.

It is also not true, that on account of lack of competition, there is not at the present time the same tendency on the part of the Canada Cement Co. to make cement of first quality at its various mills, as there always was. While the Canada Cement Co. have 11 mills, there are 14 other mills in Canada, which are all operated independently of one another and of the Canada Cement Co.; but to be fair, is it not a fact that the four largest cement companies in the United States, in fact the four largest in the world, have always followed the policy that you so severely criticise, namely: of putting under the same label the cement manufactured at their different mills, and shipping to customers from the mill having the lowest freight rate to the point of delivery? Large savings can be made in this way, and I believe it is the proper way, for it is undoubtedly according to the natural laws of commerce, and enables the manufacturer to obtain a fair mill price for his product, and the consumer, who saves in freight, is able to obtain his cement cheaper than if it had to be hauled a long distance.

The Atlas Co., for instance, has mills at Hudson, N. Y., North Hampton, Pa., and Hannibal, Mo. The Universal Co. has mills at Chicago, Ill., Pittsburgh, Pa., and Buffington, Ind. The Lehigh Co. has mills at Allentown, Ormrod, West Copley, Foglesville and Newcastle, Pa.; Wellston, Ohio; Mitchell, Ind.; Mason City, Iowa, and Metaline, Wash. The Alpha Co. has mills at Catskill, N. Y.; Easton and Martin Creek, Pa., and Manheim, W. Va. Each of these four companies, it will be noted, has a number of mills, scattered from the Atlantic to the Pacific, and each company has its one brand under which cement from all of its mills is sent out.

There are, of course, other cement companies operating in the same way, but the ones named are the largest in existence, among the oldest, and probably the most successful. Under the circumstances it would seem that the Canada Cement Co. has only followed in this particular feature the well-defined lines long since laid out by

the leading cement manufacturers in the world. I spent several years managing one of Canada's earlier Portland cement companies, and since selling out my interests have been a very large buyer of cement. I can truthfully say that I have had cement from at least eight of the Canada Cement Co.'s mills, and from a standpoint of uniformity, there is no question in my mind but that there never was produced before in Canada, such even and uniform cement as is being manufactured by the Canada Cement Co. to-day.

There is the keenest competition between the chemists of the Canada Cement Co.'s various plants to keep the standard of each individual mill up to that of the others, and as all reports are sent direct to headquarters, where experienced men are in charge, anything unusual, either good or bad, is immediately detected, and reckoned with for the future.

The quality of the cement produced at any one mill or in fact at any number of mills, depends largely upon the management, and it is a very easy matter for any individual mill to make irregular or non-uniform cement if the management is not right. On the other hand it is just as possible to produce uniform cement at a number of mills operated jointly under proper management.

I have no interest whatever in the Canada Cement Co. or in any other cement company, but the methods of the Canada Cement Co. since its formation have not been such, in my estimation, as too many papers are willing to adversely criticise, based on information received sometimes from prejudiced parties, and sometimes from parties who are writing just for something to do, without realizing that they are looking at the matter from their particular side only, and possibly injuring others without benefit to themselves.

Kennedy Stinson.

President Stinson-Reeb Builders' Supply Co., Ltd.
Montreal, Que., Oct. 24, 1911.

Freight Steamers Equipped With Conveying Apparatus.

Sir: The description of the self-discharging bulk-freight steamers "Wyandotte" and "Alpena" in your issue of Oct. 19, together with your editorial notice on the subject, may possibly lead to somewhat erroneous conclusions.

The general design for these ships was made by us primarily to meet a problem in the transportation and handling of 4-in. crushed stone, and its adaptability to handling coal is merely incidental. The design of hull and arrangement of tanks and hoppers is original with us, and it is gratifying to know has proved to be admirably adapted to the purpose.

We beg, however, to point out that some of the figures are in error as would doubtless be readily apparent if the hull dimensions were complete. The "Wyandotte" was built with a 286-ft. keel and a 306-ft. over all length, with 45-ft. beam, and 24-ft. model depth. She was designed to and did carry 3,000 tons of stone on 15-ft. draft; the latter figure was determined by harbor conditions at loading terminal. The "Wyandotte" was afterwards lengthened 60 ft. and the inclined conveyor to deck changed to the type of the "Alpena." She now carries nearly 4,000 tons, and the "Alpena" about 5,000. Further details of these ships will be found in the "Marine Review," November, 1909.

While the design shown has proved its ability to handle coal, its tonnage capacity is relatively small, ordinary ¾-in. lump and run-of-mine coal averaging about 42 cu. ft. per ton against about 24 for 4-in. stone. Designs have been prepared, however, for self-discharging coal carrying ships up to 15,000 tons cargo capacity, and careful computations made of cost of movement, including discharging. The design you refer to, with bucket elevator amidship and two boom conveyors on deck, is also our own.

Coming now to the implied adaptation of this type to handling ore: So far as the great ore movement on the Great Lakes is concerned the type is not available at all. There are several reasons for this, any one of which would be conclusive, as follows:

The first and probably most important is that the great bulk of the ores will not flow. The cohesiveness of the ore body is so great that the big grab buckets now used in unloading will often dig a perpendicular face into the cargo. This cohesiveness is chiefly due to moisture and the great preponderance of fine particles in the aggregate; possibly also in part to magnetic properties of the ore. At all events no conveyor system depending on gravity feed can handle this material. Some of the ores coming to the Atlantic coast, as some Swedish and Newfoundland ores, would lend themselves to the conveyor system without difficulty.

The iron ore movement of the Lakes, moreover, from the very nature of the business, must always flow in large volumes through certain channels in order to make production commercially possible, and the conditions which you assume do not exist. They have existed in the past but are no more.

A conveying plant to remotely approach the dispatch now given by shore equipment would absorb far too large a proportion of the displacement of the ship, and thus not only reduce her weight-carrying capacity but further handicap her in investment and maintenance. Where deep drafts are available, as at sea, this argument loses much of its force. The question of space does not, of course, enter into the question in an ore ship because of the high volumetric weight of the cargo.

A few words supplementary to your remarks as to package freight: The handling of package cargo does not anywhere approach in speed the performance of the so-called "railroad lines" on the Lakes. In these ships a continuous line of shaft extends all fore and aft between decks with double friction drums abreast of each hatch, which latter are spaced about 24 ft. centers, and two pennants can be kept constantly hoisting out, or "striking down" as the case may be, at each hatch. Freight is trucked through wide gangways which will pass two lines of trucks with their loads.

Engineering News might also help to put to rest the habit of classing every ship with her machinery aft as of "lake type" when coast and European harbors and shipyards are full of them and have been for years. All the recent fleet colliers of the U. S. Navy are so built, and dozens of tankers and bulk cargo ships may be seen in New York Harbor every week. It is, of course, the logical and economical way to build a cargo ship though probably more highly developed on the Lakes than elsewhere.

Babcock & Penton.

17 State St., New York City, Oct. 27, 1911.

Why Not Open the Door for Promotion To U. S. Assistant Engineers Now in the Service.

Sir: You made an excellent plea for the Assistant U. S. Engineers now in the employ of the Corps of Engineers, U. S. A., when the question of increasing the personnel of the corps came up some months ago. Now it is proposed to admit a few younger men from civil life. Is the cause of the older and more experienced men a hopeless one? Is it too late to do more work in their interest?

Congress meets before the proposed examinations will be held and it is thought by some that your paper with right and justice on its side can yet do something for the men who have given half a life-time or more to work in which it is proposed to open the door for promotion only to younger and inexperienced men.

Is it right to reject well qualified and deserving men and accept men who though they may have good material in them are now lacking in experience?

The most humble private in the army or the most humble sailor in the navy can, with sufficient application, become eligible for a commission, yet here are engineers of good birth, scientific education and evincing experience not even considered when an opportunity for promotion occurs.

A public appeal through your paper to the President of the United States will be a reasonable proceeding.

This is a matter which means much to the men in the service.

Yours truly,

E.

Philadelphia, Nov. 11, 1911.

[As the law now stands, the remedy our correspondent desires would have to be sought at the hands of Congress, rather than from the Executive. We believe that favorable action might be secured from Congress if some engineering society of standing would undertake systematically and intelligently to present the matter to the proper committees of Congress; not by a single visit of a delegation or committee of engineers, but by arranging for a competent representative to explain the matter to the members of the committee, so that it may be clearly understood.—Ed.]

An Automatic Sluice Gate for Spillway Crests.

Sir: Answering Mr. Paul M. [illegible]ach's letter published in Engineering News of Oct. 19, 1911, p. 474, I wish to refer this gentleman to the description of a new type of automatic flashboard, very adaptable to the crest of spillway dams, published in Engineering News, Dec. 29, 1910, p. 711.

Observations made on three flashboards of this type have shown that a head of about 1 in. of water on the flashboard's crest was sufficient to cause the flashboards to fall down so that a certain amount of water could pass and thus keep the pond level at a constant elevation.

On one such structure in Europe at certain times of the year logs used for pulp manufacture are passed for several days over the flashboards without causing any disturbance or damage to any part of the structure. This type of construction has been designed with panel lengths of 66 ft. and a height of 7 ft., with the counterweight located above or below the water level.

The flashboards used in connection with most dams are wholly inadequate. Either they are built in such a substantial manner that they are hopelessly unmovable in times of flood, or else they are of such flimsy construction as to be washed away at times of ordinary high water.

Selecting the Dells dam spillway for instance, as described in Engineering News Oct. 19, 1911, p. 482, it will be noticed that the aggregate width of the 4-in. I-beams forming part of the structure that held the flashboards decreased the width of the spillway by 14 ft., to which figure should be added the contraction caused by the structural steel shapes and the debris fastened to the latter. Assuming a head of 6 ft. of water over the crest of the dam, and a discharge coefficient of 0.80 for the 4 x 5-ft. sluice gates, the total discharge capacity of the whole structure was about 1,400 sec.-ft., whereas a discharge of 23,000 sec.-ft. had been recorded at Neilsville. As a spillway should be designed to take care of at least 25 or 35% excess of the maximum observed discharge (based on a recorded flow of several years) it was, in addition to providing too little spillway capacity, very unwise to obstruct the spillway by a fixed structure for holding the flashboards in place.

Eugene Lauchli.

2 Wall St., New York, Nov. 1, 1911.

A Report on an Underground Rapid Transit System for Chicago.

The new Chicago Subway Commission recently appointed by Mayor Harrison and consisting of Messrs. E. C. Shankland, J. J. Reynolds and John Ericson, reported on Oct. 21 to the Transportation Committee of the City Council, the Mayor and others, presenting the routes which it favors for subways and general designs for construction.

In determining routes, the following considerations were held to be governing: (1) the best transportation possible under present financial limitations is to be sought; (2) it is to be assumed that the main business district will always remain but with need of facilities for free expansion; (3) the initial subways should provide rapid transit from the west, south and north sides to the business center and to any other part of the city; (4) initial subways must be a link in the ultimate rapid-transit system; (5) cost of subways is to be kept as low as possible consistent with good construction, latest requirements and practical operation; (6) there should be no grade crossings, switches or turnouts, but an unbroken and continuous track from one end of the subway to the other; curves and grades should be easy and few, and the construction should safeguard the public and employees in every possible way; (7) the routes should be selected to meet these requirements but to do the least damage to private property; (8) there should be through routes between all divisions so far as consistent with feasible operation and proper facilities should be arranged for convenient transfer; (9) four-track or low-level subways in the "loop" district are impractical in streets of 80 ft. or less width; (10) the removal of the present elevated-railway loop is to be sought; (11) initial subways are to be operated in conjunction with present transportation systems.

The Commission reported that it had examined

all projects heretofore presented but that none met the above limitations.

The Commission had visited New York, Boston and Philadelphia to study the subways there and the members believed that the conditions in Boston were more nearly ideal than elsewhere. The plan there of having outlying surface lines converge and deliver their short-haul traffic to elevated railroad trains was considered very satisfactory.

The several subways proposed by the Commission are shown in the accompanying figure, which is arranged from one appearing in the "Electric Traction Weekly" of Nov. 4.

RAPID-TRANSIT LINES.—Two initial subways for elevated-railway trains were recommended, known respectively as the North-Southwest and the South-Northwest.

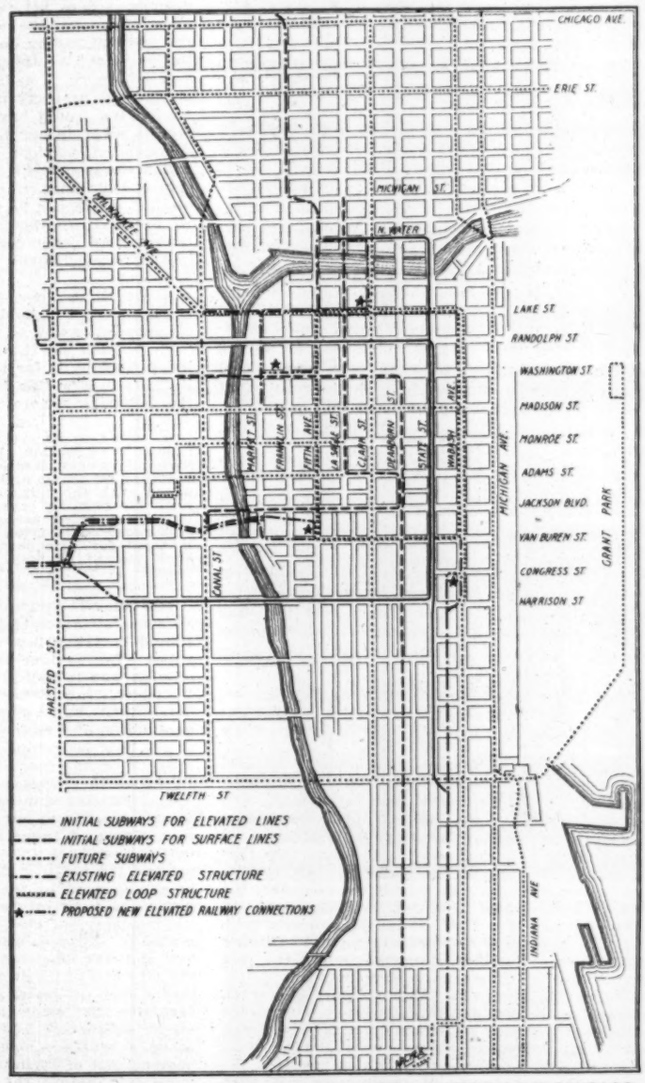
The North-Southwest is a proposed double-track subway line from Wells and Kinzie Sts. to Halsted and Pearce Sts., connecting the Northwestern Elevated Ry. with the Metropolitan West Side Elevated Ry. The tracks are to be carried from the elevated structure by incline, open approach and subway in North Water St.; they drop still more to a river tunnel at State St. but rise again on the south side of the river under State St., pass under the subway of the South-Northwest line at Randolph St. and rise to a high level which is held along State and Harrison Sts. until they have to drop to a river tunnel under Harrison St. West of the river they rise to a portal at Harrison and Desplaines Sts. and continue by an open approach and incline on private right-of-way to the elevated structure.

The second initial line—the South-Northwest route—is a double-track subway connecting the South Side Elevated Ry. with the Oak Park Elevated. Transition from the subway structure is by incline and open approach on private right-of-way between State St. and Wabash Ave. near 14th st. The subway portal is on the north side of 12th St.; the line continues north under State St. to Randolph, and west under Randolph to La Salle, where the tracks are depressed to pass under the river at Randolph St. West of the river they rise again to Desplaines St. and by open approach, incline and elevated structure are carried across Halsted and north in Greene St. to a connection with the Oak Park Elevated Ry.

Nine stations have been laid out but their exact locations have not been announced, since this is a matter to be decided in conference with all interests involved. The stations along the two subways in State St. would serve as transfer points between the two lines. The two subways will be on the same level, except where necessary for one to pass under the other.

It is proposed to send the express trains of the several elevated lines into the subways instead of around the present loop. If the loop is retained, the local trains may still be run on it, but if the old structure is abolished the local trains may use the present stub terminals. The Commission has suggested that the stub terminal of the Oak Park Elevated line in Market St. be connected with the tracks in Lake St. and Fifth Ave to form a short loop by which the entire capacity of the local tracks can be developed. A similar proposal is made for the Metropolitan South Side and Northwestern Elevated stub terminals.

The combined capacity of movement of the present system is 622 cars per hour in the rush period on the loop and 293 cars per hour in and out the stub terminals, making a total of 915.



PROPOSED SUBWAYS FOR THE BUSINESS DISTRICT OF CHICAGO.

(Reproduced by courtesy of the "Electric Traction Weekly.")

With the two initial lines of subway and the stub terminals, the capacity is increased to 1,893 cars per hour, or 107%. If the short loops were substituted for the stub terminals, the capacity would be 3,200 cars per hour, or 250%. The Commission does not think it necessary to retain any part of the present loop since the full capacity of the system may be developed without it. The estimate of the cost of these two lines was given as shown in the accompanying table.

SUBWAYS FOR SURFACE CARS.—The Commission reported that the wisdom of having subways for surface cars was questionable, but that they had presented plans for such a system in addition to the subways for elevated trains. Two lines were definitely described, known as the North-Southwest and the South-Northwest routes, similar to the two rapid-transit lines already described.

The North-Southwest line begins at Michigan St. in La Salle, and the tracks are carried under the river on a low level; at Randolph St. they rise to a high level and proceed to Adams St., going east in Adams to Dearborn St., thence south in Dearborn to Jackson Boulevard and west in the latter to about Fifth Ave., where they descend to a river tunnel. West of the river, at about Desplaines St., they rise to a high level, with portal and open approach on the right-of-way of the Metropolitan West Side company.

The second line for surface cars, the South-Northwest, begins at 16th St. and runs north under the railroad yards at a high level until it descends in Dearborn St. to pass under the east and west subway for elevated trains at Harrison St. From here it rises to a high level and goes north to Washington St. and west to a connection with the present Washington St. tunnel, thence through this to the surface at Washington and Clinton Sts. The estimated cost of these two lines is shown in the accompanying table.

The peculiar bend in the first line for surface cars has been introduced to bring this line east to the South-Northwest to permit of easy transfer. The cost of a four-track subway in Dearborn St. prevented the use of more than one block there, and this was taken opposite the post office, where there were few difficulties. Transfers from one line to another may also be made at the intersection of Washington and La Salle Sts. A transfer station between the elevated trains and surface cars is possible at this point and also at the junctions of Randolph and La Salle Sts. and of Harrison and Dearborn Sts.

Two more double-track inlets are proposed for the surface car subways on Monroe and Adams Sts. It is believed that the capacity of the present street-car lines can be raised from 1,037 cars per hour to 2,020 by the subways and a rearrangement of surface loops. The addition of the two extra inlets brings this up to 2,380 cars per hour.

FUTURE REQUIREMENTS.—In addition to these subways, various lines were also mentioned as necessary to meet possible future requirements. These have been laid out on the accompanying map. Among these is a belt line to be on an all-elevated, all-subway, or a mixed structure, with trains or moving sidewalks. This would give access to the lake front and the proposed harbor and would provide for transfer from one rapid-transit line to another. Details of this proposal are not available.

It was noted that money was available for the construction of the rapid-transit subways, but not for the surface-car lines unless the transportation companies contribtued some $5,000,000 as permitted by the present franchise ordinances.

Estimated Cost of Chicago Subways.

Initial Subways for Elevated Trains.

Street sections:	
Two-track, 1.47 miles @ $1,454,000	$2,140,000
Four-track, 0.682 mile @ $2,425,700	1,655,000
River sections:	
Two-track, 1.705 miles @ $1,848,000	3,150,000
Building Protection	375,000
Temporary Sewers and Water	600,000
Stations (nine)	1,000,000
Total (3.857 miles)	$8,920,000
Engineering and Contingencies (10%)	892,000
	$9,812,000

Subways for Surface Cars.

Street sections:	
Two-track, 2.46 miles @ $1,454,000	$3,580,000
River sections:	
La Salle and Washington St. (0.664 miles)	2,000,000
Jackson Blvd. Tunnel (0.568 miles)	1,050,000
Building Protection	500,000
Temporary Sewers and Water	450,000
Stations (eight)	900,000
Total (3.692 miles)	$8,480,000
Engineering and contingencies (10%)	848,000
	$9,328,000

The Building Laws of Illinois are to be revised and codified by a commission authorized by the last session of the legislature. Dr. N. C. Ricker, Professor of Architecture at Illinois University, has been made chairman of the commission. Prof. I. O. Baker, Dean of the Department of Engineering at the same institution, is also a member. The other members are: R. E. Schmidt, W. C. Armstrong and W. S. Stahl, Chicago; W. H. Merrill, Lake Forest; and G. J. Jobst, Peoria.

Paving Over Gas Mains and Capitalization of Profitable Contracts As Elements in Rate Making: Decision of the New York Public Service Commission in the Kings County Lighting Case.

An opinion and order of the Public Service Commission for the First District of the State of New York was published on Oct. 20 in the case against the Kings County Lighting Co., looking to the reduction of rates for gas in the 30th Ward of Brooklyn. This decision follows rather closely the principles outlined in the decision of the Commission on gas and electric rates of the Queens Borough Gas & Electric Co., noted at length in Engineering News, Aug. 31, 1911. The later decision goes farther than the Queens Borough case in discussing two elements which have been claimed to enter into "fair value of property actually in the public service"—the matters of paving over mains and capitalization of profitable contracts, which did not arise in the former case.

It appears that the rate complained of is $1 per M. cu. ft. supplied to private customers. While the petitions for these proceedings were pending, negotiations were made between the company and certain civic associations of the 30th Ward looking toward a settlement. The company proposed to reduce the rate to 90 cts. for 1911, 85 cts. for 1913 and 80 cts. for 1914 and 1915, but these terms did not meet the approval of the complainants and the hearings proceeded.

It may be noted in passing that the company has an old contract for lighting what was the town of New Utrecht, by which it receives the equivalent of $1.76 per M. cu. ft., covering the cost of caring for the lamps as well as of gas.

The Commission, in its investigation, found the Kings County Lighting Co. to be the successor of the Kings County Gas & Illuminating Co., incorporated in 1889. When the old company was merged into the new one, June 30, 1904, the assets were stated as $2,586,778. The day after the readjustment they were $4,846,773; over night the concern had more than doubled the outstanding securities, issued $2,000,000 of capital stock where there had been $1,000,000 and added $1,112,000 to the outstanding $1,000,000 of funded debt. Such statements of the book assets and liabilities as could be found were of such doubtful validity that they were not considered in the determination of fair value.

However, the change in assets and liabilities recorded between July 1, 1904, when the new company took over the old one, and Dec. 31, 1910, the date of investigation, were studied. Addition to plant of $646,079 was shown, but nothing was written off for withdrawals or retirement capital beyond small and minor amounts. Also, previous to 1909 there was no reserve for depreciation. Taking such facts into consideration, together with $2,040,940 added to capital account at the beginning of the company, without any equivalent in property, the Commission found that the unimpaired investment represented by plant could not be more than $2,600,000, accepting the book entries.

An inventory and appraisal of assets was made by the Transportation Department of the Commission under Mr. E. G. Connette. The company also called two witnesses on the subject—Mr. W. A. Baehr and Mr. W. W. Randolph. Comparison between figures of these witnesses and of Mr. Connette appears throughout the decision of the Commission, but greater weight was placed on the estimates made by Mr. Connette.

A net cost of plant of $1,561,268 was allowed, and this was increased by land, preliminary and development expenses and working capital to $2,500,000, as of Dec. 31, 1910. The company argued for the inclusion of buried mains at the cost of laying under present conditions, including the pavements which are now in place. This was not allowed by the Commission, nor was the capitalization of the favorable street-lighting contract admitted. Such matters as accumulated depreciation, development expenses, increase in land values, working capital, and going value were treated quite as in the Queens Borough County case.

The Commission concluded that a fair rate of return for the years 1911 to 1913 should not exceed 7½%, compared with the 8% allowed in the Queens Borough rate case above mentioned. It was held that the latter company did not operate under as favorable conditions as the other and that the rate of return should reflect that fact. It was pointed out that this return of 7½% on the whole fair value was equivalent to a dividend of 10% on stock and 5% on bonds, for a ratio of 50%, or to 9% dividends and 6% bond interest for the same ratio.

In estimating the actual operating cost of producing the gas to be added to the fixed charges determined from fair value and fair return, a figure of 25 cts. per M. cu. ft. was allowed in place of the 23.6 cts. reported cost in 1910. The Commission held that the company was being operated with greater efficiency than might be expected under good though not extraordinary management, so that a part of the benefit should be allowed to the company. This in effect partially offsets the action of the Commission in refusing to accept as reasonable the recorded performance of the company as to condensation and leakage, it being held that the loss should be lower with good management. The total amount to be generated was computed for 1911, 1912 and 1913, with this last fact in mind, and multiplied by the unit cost of operation for adding to the fixed charges; this sum was apportioned over the amount of gas sold with the result that the fair rate was found to be 85 cts. per M. cu. ft. from Nov. 1, 1911, to Dec. 31, 1912, and 80 cts. from Jan. 1, 1913, to Dec. 31, 1913.

Allowance for Paving Over Mains and Services.

It has been stated that the company argued for the inclusion of a fair return on the cost of repaving the streets where mains and service pipes were laid, not according to the kind of paving in place at the time the work was done, but according to the kind and cost at the time of the appraisal. The decision of the Commission is so emphatic on this point that it may be quoted directly.

The practical effects of such a theory are interesting and important. Suppose a locality at the time a gas company was started and its pipes laid were content to have unpaved or cheaply paved streets, cobblestone, macadam or gravel being used. Suppose that the people come to demand better paving, being dissatisfied with earlier conditions, and that asphalt, brick or granite block with a concrete base is laid throughout the area. Naturally, the people appreciate that they must pay the cost of the repaving; but according to the theory of counsel for the company, the gas **consumer** must also pay more for **gas.** In other words, every time the streets are improved, not only do taxes or assessments go up, but higher gas rates are justified, notwithstanding the fact that the company may not have paid one dollar in connection therewith. If this theory is correct, citizens must consider in connection with every civic improvements its effect upon rates for gas, electricity, telephone service, water, transportation and every other service which involves the use of the subsurface of the streets. If such improvement increases the cost of reproducing the undertaking supplying such service, higher rates will thereby be justified than would be reasonable before such improvement is made.

Applying the theory of counsel to the case in hand, he asks that **in toto** about $250,000 or $300,000 be added in determining the "fair value" of the property, such sum including not merely the net cost of the paving, but "overhead charges" amounting to 20% or thereabouts. A return of 10% thereon would be from $25,000 to $30,000. Upon the basis of actual sales for 1910, this is equivalent to from 4 to 5 cts. per thousand. Thus, the net result of counsel's theory is that this Commission is asked to fix a rate higher by 4 or 5 cts. than would otherwise be reasonable, and the reason offered in essence is that since the Kings County Co. laid its mains and services the City of Brooklyn and later the City of New York has materially improved the paving over those pipes without expense to the company.

The company's counsel apparently relies upon a single thesis to maintain his theory. He may not claim that the pavement is the property of the company, for it is not in any degree. The company may not alter the pav[illegible] without the city's permission, nor sell, tra[illegible] or remove it, and in case the company does [illegible] up its pipes and leave the street, the pave[illegible] must be restored. Secondly, the company [illegible] not lay the new paving. It was laid by [illegible] city after the company's pipes were in the gro[illegible] In the third place, the new paving represents [illegible] expenditures upon the part of the company. [illegible]s fact is important, for it is conceivable [illegible] a company might not own certain property [illegible]ght not have actually constructed it, and y[illegible] expense of such construction, if paid by th[illegible]mpany, might properly be included in the am[illegible] upon which the company would be entitled to earn a fair return. But in this case, the new [illegible]vement under discussion does not represent a[illegible] investment or expenditure by the company. [illegible] relaying of the original paving does and it has been included in "net cost," as above set forth.

If one were to estimate the cost to reproduce as new the property that exists to-day, the present paving would have to be replaced when the streets were opened for the laying of mains and services. Apparently this is the only basis upon which the company's contention is founded. The cost-of-reproduction method may be the only method which can be used in some instances, but to follow it to the last extremity in all cases, ignoring all other considerations, not only leads to absurd conclusions, but runs counter to judicial decisions.

In Smyth vs. Ames, 160 U. S., 466 (1898), Justice Harlan said: "We hold, however, that the basis of all calculations as to the reasonableness of rates * * * must be the fair value of the property being used by it for the convenience of the public." As to how this fair value is to be estimated the following general method is indicated:

> In order to ascertain that value, the original cost of construction, the amount expended in permanent improvements, the amount and market value of its bonds and stock, the present as compared with the original cost of construction, the probable earning capacity of the property under particular rates prescribed by statute, and the sum required to meet operating expenses, are all matters for consideration and are to be given such weight as may be just and right in each case.

The court is careful to add also that there may be other elements besides those enumerated that should be taken into consideration in fixing fair value. The evident purpose of the court in this opinion was to indicate that there is no one rule by which "fair value" for rate purposes can be determined. Fair value means equitable value and applying equity to the case in point, it is difficult to see how the company is justly entitled to earn a profit on the cost of pavement laid and maintained at the expense of the city.

The judicial opinion that counsel for the respondent company quotes to support his contention is that of Judge Hough of the Circuit Court in the New York City Eighty Cent Gas Case, involving the right of the state to reduce the price of gas charged by the Consolidated Gas Co. The difference between book value or original cost and replacement cost or cost of reproduction of mains and services was in this case about $5,500,000, and was admitted to be due to the fact that the city had at its own expense built costly pavements over the mains of the company, and to the fact also that since the laying of the mains the street subsurface had become so crowded with other subsurface structures as to increase the present cost of laying mains. Most of the mains were laid before the streets were paved with asphalt and at a time when the street was not so congested with other pipes and services. The city and state contended that the original cost should be taken as a basis for valuation. The company, on the other hand, contended that the present cost of replacing the mains and services should be used. The Special Master reported in favor of the company's contention and his report was approved by Judge Hough of the United States Circuit Court in his opinion of Dec. 20, 1907.

When this case came before the U. S. Supreme Court on appeal, the city and state renewed their contention that original cost rather than replacement cost should be used in valuing mains and services. The opinion of the Supreme Court, however, leaves this matter undecided. The opinion does not fix a total valuation of the property, but, after reducing the value of the franchise of the company and altering other estimates, comes to the conclusion that the rates fixed by the state were not so low as to warrant the intervention of the court, at least until there had been an actual trial of the rates. Justice Peckham, however, in delivering the opinion of the court, made

the following statement (Willcox vs. Consolidated Gas Co., 212 U. S., 19, decided Jan. 4, 1909):

And we concur with the Court below in holding that the value of the property is to be determined as of the time when the inquiry is made regarding the rates. If the property, which legally enters into the consideration of the question of rates, has increased in value since it was acquired, the company is entitled to the benefit of such increase. This is, at any rate, the general rule. We do not say there may not possibly be an exception to it, where the property may have increased so enormously in value as to render a rate permitting a reasonable return upon such increased value unjust to the public. How such facts should be treated is not a question now before us as this case does not present it. We refer to the matter only for the purpose of stating that the decision herein does not prevent an inquiry into the question, when, if ever, it should be necessarily presented.

Although the wording of the above, read in connection with the briefs and the opinion of the lower court, might possibly be construed to settle the matter in favor of the inclusion of the cost of pavement laid at the expense of the city, it is not believed that it was so intended. The question of paving over mains is so unique that it should not be assumed that the court intended to dispose of it in the above general phrases in relation to allowing the company the benefit of any increase in the value of its property. At any rate, this principle will only apply in case pavement laid by the city be deemed to be "property which legally enters into the consideration of the question of rates." This is in fact the whole question at issue, and the court has left it entirely undecided. It did not fix the value of the mains or approve the findings of the lower court in regard to such value, and the pavement is not the property of the company. The court intimates, however, that "the value of real estate, plants and mains" may be too high, but that, inasmuch as the rate proposed will probably upon trial yield a reasonable profit even at these valuations, it is unnecessary to go further in the present case, and that is the nub of the whole question; all else is dictum.

It should be noted, further, that in none of the cases cited in Judge Hough's opinion was the question of paving over mains definitely referred to or decided. Indeed, all of the gas rate decisions that have been found, where the question is discussed, are definitely opposed to the inclusion of cost of pavement laid by the city. In Cedar Rapids Gas Light Co. vs. Cedar Rapids, 120 N. W., 966, 970, decided May 4, 1909, after the New York case above cited, the contention for increased value to pipes and mains was disapproved by the Iowa Supreme Court. The following is from the decision of the court:

The sum of $43,580 was added owing to the alleged increase of value of pipes and mains because of being underneath the pavement. The company had laid them before the paving was done, but it is argued that, as the value of the mains and pipes is to be estimated when they are in the ground, what it would now cost because of the pavement to put them there should be included in determining their present value. If so, the contingency of having to remove them at the expiration of the franchise also should be taken into account. Moreover, the fact that most of the paved streets are paralleled by unpaved alleys or parkways, in which pipes might be laid without removing the pavement, and possibly with less danger from electrolysis, is entitled to consideration. Nor is it to be forgotten that pavements yield to the ravages of time, and that with new pavements new pipe may be laid. Undoubtedly, the values of the pipes are somewhat enhanced because of their location, but the entire immediate cost of opening and replacing the pavement is not the criterion for value which should be adopted.

The Wisconsin Railroad Commission has ruled that in a valuation for rate purposes the cost of reproducing pavement over mains will not be included unless such pavement has been laid at the expense of the company. See State Journal Printing Co. vs. Madison Gas & Electric Co., decided Mar. 8, 1910 (4 W. R. C. R., 501, 554); Ashland vs. Ashland Water Co., decided Nov. 1, 1909 (4 W. R. C. R., 273, 307); Racine vs. Racine Gas Light Co., decided Jan. 27, 1911 (6 W. R. C. R., 228, 240).

Capitalization of Contracts.

It has also been stated that the company desired to add to fair value the capitalized value of the contract for street lighting mentioned. This contract has yet five years to run and it was admitted to be an exceedingly profitable one. The valuation of the contract, according to the company's witnesses, was placed from $50,000 per year up. In computing the capitalized value, an annual profit of $90,000 was taken on a basis of 4½%, but the fair return on this capitalized value which was sought was 10%. Thus an annual profit of $90,000 from the favorable street lighting contract was to be made to yield $200,000 annually, the $110,000, of course, coming from the ordinary customers. The decision of the Commission is well quoted on this point:

The contention of the company as represented by the testimony of this witness in substance is that the profits from this contract for its remaining life shall be capitalized, that the amount thus reached shall be added to the fair value of its property and that the rates shall be such as will provide a fair return thereon. In other words, the city or the taxpayers must pay an exorbitant price for street lighting, and yet the general consumers must pay enough to yield an ample return (10% is urged) upon the capitalized value of such abnormal profits, capitalized upon a basis of 4½ or 5%. The absurdity of such a contention is apparent. Paraphrased, it is that the more the city pays the more the consumer must pay. If there is any relationship between these two factors, it is that the more the city pays, the **less** the consumer should pay, and this has been recognized in many franchises for water and lighting plants. Indeed, the original contract and its history indicate that street lighting and the price obtained therefor have always been very important factors, and at the beginning were the chief concern of the company. Apparently, the original plant was built principally with a view to this business, and the contract was a very important inducement to the company to begin operation. It is obviously unfair that this very contract should be used to make the public pay a higher rate than they otherwise would.

The argument of the company proves too much, for, if it is correct, it could be argued that every contract should be similarly treated. The public lighting contract resembles other contracts between company and consumers. All are property, and presumably all are profitable. Those that are could be capitalized if this one may, and the more profitable they are, the higher must the rates to others be placed. Conversely, if any one should not be profitable, the capitalized loss should be subtracted from the fair value of the other "property," and the rates lowered accordingly.

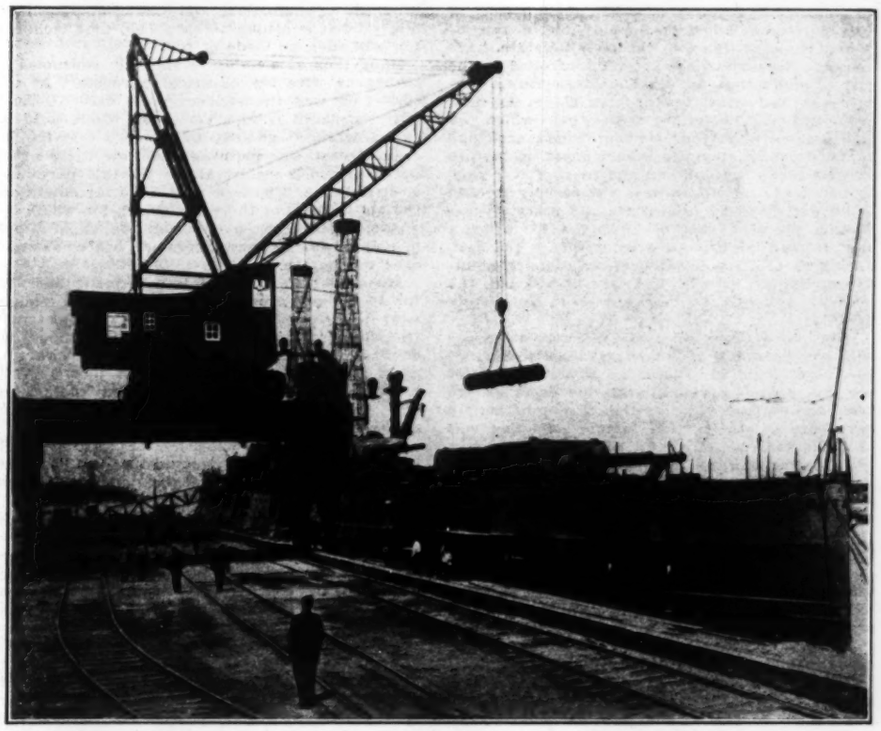
It should be noted, further, that the company does not claim that the contract itself represents any investment or that any deposit, fee or payment was required by the authorities.

The Commission can find no reason in law or equity which would justify the capitalization of the street lighting contract and the inclusion of such capitalization in the "fair value" upon which the company is entitled to earn a fair return from the sale of gas to general consumers. It is unnecessary, therefore, to consider the methods of determining its value.

A Locomotive Crane Mounted on a Gantry to Serve Both Sides of a Pier.

A revolving locomotive crane mounted on a gantry has been recently installed on a pier at the shipyards of the New York Shipbuilding Co., at Camden, N. J. The accompanying illustration shows this crane carrying one of the boiler drums of the U. S. Battleship "Utah," whose machinery and equipment were described in our issue of Nov. 2, 1911. The crane is driven by electric motors and is designed to lift a load of 35 tons at 25-ft. radius or 15 tons at 65-ft. radius. A 35-ton load can be hoisted at 15 ft. per min. and a 15-ton load at 30 ft. per min.

The crane is rotated on a roller bearing of the usual type by the same motor used for raising and lowering the boom. The speed of rotation is 2 r. p. m. The same motor is used also for moving the crane back and forth across the gantry. This movement is produced by means of a wire cable, attached at each end of the gantry, which is wound around a drum mounted under the center of the crane and driven from the motor shaft through worm gearing. By this arrangement, the crane is held positively at any position on the gantry.



LOCOMOTIVE CRANE ON A GANTRY INSTALLED AT NEW YORK SHIPBUILDING CO.'S PIER AT CAMDEN, N. J.

The gantry is moved along the pier by a motor mounted at its mid-span. Power is transmitted from the motor through steel shafts and gearing to one truck at either end of the gantry.

The speed of movement across the gantry is 25 ft. per min. and the gantry itself travels along the pier at 150 ft. per min. Higher speeds would have been used, we are informed by the builders, the McMyler Interstate Co., of Cleveland, Ohio, except for the lack of available power. Electricity for the various motors is supplied through the protected third-rail which can be seen along the right-hand side of the pier in the illustration. The third-rail system is used also for the rotation of the crane and for the movement across the gantry.

The Annexation of Hyde Park to Boston, Mass., was authorized by popular vote on Nov. 7, carrying by a large majority in Boston, and a small one in Hyde Park. The vote becomes effective on Jan. 1, 1912, when the first enlargement of the area of Boston since 1874 will take place. The annexed area comprises 2,055 acres, against 17,193 acres in all of the present Boston. The added population is 15,507 (as of 1910). This is the beginning of the Greater Boston discussed for some years past.

Alloys.*

By W. R. WHITNEY,† Past Pres. Am. Chem. Soc.

I want to call attention to the possibilities in the way of useful discoveries, which may well lie more nearly within reach of some of the members than they realize, because of their particular knowledge or possession of special materials. For example, it frequently happens that one manufacturing company produces a new metal or alloy for some particular use, which, owing to lack of general study, may remain the sole use for a long period of time. So also, those who use the very modern metals, tantalum, tungsten and molybdenum, have been engrossed with applications to a single field, and have hardly been able to look carefully into others. It is often through the interchange of information across the gap between quite remote fields that useful advances are made.

It occurred to me that even an imperfect review of some of the relatively recent metals might not come amiss. Probably few realize the rapidity with which new metals are coming into use, particularly in alloys. There are in all approximately 50 metallic elements, though most of our important industries employ but a few of them. Some of these, in the metallic state, have market prices which are not yet controlled by the cost of production, nor by the infrequency of occurrence, but rather by the lack of development of a utility. Beginning with gold, which we may assume is the one element whose exchange value depends upon its commonness in nature plus its cost of production; and passing over iron, copper, lead and zinc, whose values may be said to be well fixed by occurrence and costs of production, we soon reach other metals, for which a new demand might well greatly reduce the cost. Among these are many whose ores occur in abundance. In the case of this type of element, the interest attached to research work is doubly great.

It is highly improbable that the cost of copper will ever be greatly changed by the discovery of new uses. This is because the world's supply of the ore is pretty well known; the demands are great and the cost of production of metal from ore have been so studied that further reduction will probably only be of what I like to call the second order of magnitude. This was not true of the metal aluminum a few years ago, and it is still possible that considerably wider uses and reduction of production costs may develop in its future.

There is apparently a much wider divergence between the occurrence of the aluminum in nature and its price in metallic state than in the case of copper. In case of aluminum, only selected and purified ores are used at present, while other compounds of it occur everywhere in nature. On the other hand, in the case of copper, ores containing even less than 2% of copper are worked for the metal. Aluminum may thus still be considered in the transition state, a state long ago passed by copper and iron, and not reached by some of the metals considered below. We have all been witnesses of the interesting advance of aluminum. From 1869-74, its properties were becoming generally known. The inefficient process by which it was then reduced from its ores made it impossible to sell the metal below $10 per lb. Advance was then made so that in the 80's the price was about $5. There was not a great demand for it at this price. In the year 1907, something like 26,000,000 lbs. of this metal were made in America alone. The price is now about 20 cts. per lb.

The element **calcium**, which a few years ago was listed only as museum specimens and at several dollars per gram, was sold in 1908 at $1.50 per lb., and could certainly be sold for a small part of this price if a greater use could be found for the metal. It slowly decomposes water, giving hydrogen, and it differs from the alkali metals in producing such a feeble alkaline solution, that it is generally harmless. It ought to serve as a good deoxidizer, and should be a very cheap metal. It is not fair to relegate it to a list of useless metals. History of the metallic arts points to these being no such list.

Thallium is an element quite similar to lead, but probably possessing some property which will some day warrant its exploitation. It is softer and heavier, and could be obtained in quantity, if a demand were created.

The elements **chromium, molybdenum, tungsten** and **tantalum**, the three latter now obtainable in wire form, are tempting elements to study in mixtures with others. Who knows the useful properties of a chromium bronze, for example?

Tellurium has long been an apparently useless metal, and any market price is fictitious, as there is but little isolated in metallic state. It is not necessary that a great use, such as a substitute for zinc in brass, should be found for it. Our industries are so great, that if a pound of tellurium added to the ton of aluminum was of benefit to the latter, the production of the necessary tellurium would be real industry.

Consider **cobalt**. The world's rate of supply of ore has been greatly augmented. It may take time to actually realize a greatly reduced cost of metallic cobalt, but we ought, notwithstanding, to realize it when uses have been developed. Our natural impulse in such a case, is to try direct substitution of one metal for another in some well developed use. Cobalt, for example, might replace nickel in most uses when the cost fell below that of nickel, but this is a second order use. A first order use would be the supplying of a want which no metal previously supplied, or supplied distinctly less perfectly.

In this connection, an interesting alloy of cobalt and chromium has just been described by Elwood Haynes in the October number of the "Journal of Industrial and Chemical Engineering," and it is altogether probable that technica. use will soon be made of it.

Many tons of metals are annually consumed as resistance wire for electrical purposes. At one time iron was the element most used. German silver replaced it in some cases, where a lower temperature co-efficient was needed and the increased cost was permissible. Now there are a dozen or more special alloys for this particular electrical use. The new ones have far outclassed the old in most of those properties for which the electrical engineer uses them. In such alloys, nickel, chromium, manganese and others are now used by the ton.

Silicon, which in 1900 was a curiosity and sold for 40 cts. per gram, is now a necessary component of special iron alloys and of high-grade transformer iron, and the world uses thousands of tons of the alloy annually. Silicon is now sold at about 5 cts. per lb. The use of this metal in other alloys is still quite limited. In the case of iron, it greatly decreases hysteresis loss and increases electrical resistance.

Boron, still a quite expensive material in metallic state, is coming into commercial use in assisting the making of solid copper castings of high electrical conductivity.

Vanadium seems to be a young wonder working metal. Its use has increased very rapidly in the past few years, but the quantities consumed are not known to us. As several companies are producing the iron alloy, it is safe to assume that it is being sold by the ton. The price for the metal in the alloy is not far from $5 per lb.

Cadmium is a beautiful metal in many respects, and it is certainly awaiting use. It is whiter and less crystalline than zinc, and doubtless the high price of nearly $1 per lb. keeps practical workers from trying it in their experiments. It should be produced as cheaply as aluminum, if there were a good demand for it.

Titanium is an element long the subject of criminal negligence. It is a high-melting ductile white metal, which, at present, is only separable from its ores at high cost. It exists in many cheap ores widely distributed in nature. It is now apparently coming into use in steel manufacture, particularly for railroad rails, and for this purpose it is fortunately unnecessary to isolate the pure titanium from its ores, an iron titanium alloy being produced directly. What will happen when the pure element has been tried in special fields, can only be surmised.

If one omits the common alloys, brass, bronze, solder, etc., and considers only possible alloys of two metals, and still confines himself to 20 of the common metals, like vanadium, manganese, chromium, boron, etc., he is interested at once to recognize that there must be 190 different pairs of binary alloys. When, in addition, the effect of varying proportions in these alloys is considered, it becomes evident that the field of alloy-research is truly a large one. Many of the alloys apparently unstudied, are those which melt at extremely high temperatures.

The brass founder who knows the upper limiting temperature of his melting furnace may at once point out that this temperature is fixed both by the life of crucibles and the particular coke or oil heating schemes with which he is familiar. If he thought that a molybdenum bronze of 30% molybdenum, would have useful properties compared with all other alloys, he might at once conclude that he must give up his alloy because of the difficulty of melting it. If it were not for the advances in our available temperatures, there would seem to be little more than amusement in considering alloys high in tantalum, chromium, titanium, molybdenum, in silico[illegible]anium, vanadium, and a number of oth[illegible]high-melting metals. But hand in hand wit[illegible] discoveries leading to isolation of such me[illegible]go also dis-coveries of alumino-thermics, o[illegible]etylene and oxy-hydrogen temperatures and [illegible]tric-furnace processes.

The time is always ripe for [illegible]tudy of new alloys with new tensile stren[illegible] elasticities, colors and wearing powers. Th[illegible]tomobile and the aeroplane have forced the al[illegible]um and iron alloys to make rapid strides, [illegible]t is natural that we should want to invent[illegible]er possibilities. The physical chemist has [illegible]ed along the way of a systematic co-ordina[illegible] of certain properties of binary, and in a fe[illegible]ses tertiary alloys. He has shown how to pl[illegible] few freezing points of two-metal and three-m[illegible] mixtures and to construct therefrom curves s[illegible]ing not only all possible alloys, but what ma[illegible]be expected in the way of segration and structu[illegible] and such effects as caused by annealing or [illegible]nching.

He has found that there is a solubility of metals in one another which varies jus[illegible] about as the solubility of substances in wate[illegible] varies. Metals may be melted together and well mixed, but the quality and permanency of the mixture is determined by just such solubility laws as control ordinary solutions. We know that in some cases well-mixed melted metals will separate into two layers if allowed to remain even a few moments in molten condition at low temperatures. They act like a mixture of water and ether. The two separated layers contain both metals, no matter what the temperature, but the quantitative composition depends on the temperature.

The other extreme of metal solubility is found in such a case as zinc-cadmium, which acts much like a mixture of alcohol and water, the two components going into solution in all proportions and remaining in solution at all temperatures. Having seen this analogy to the facts of solubility of substances in water, it is natural to search among the metal mixtures for all the peculiar kinds of solution observed in aqueous solutions.

Two such classes interest us at once. They are (1) those corresponding to aqueous solubilities where temperature widely influences the quantities dissolved, and (2) those in which the solvent (as water) combines with the dissolved substance more intimately than by simple solutions, as by chemical combination. In the case of zinc and lead we have one of the metal alloys of limited solubility. If these two metals are well mixed in liquid state, they separate into layers—one, the zinc, carrying a few per cent. of dissolved lead floats of an alloy made up of lead carrying a few per cent. of dissolved zinc. In general, the quantity of the one metal dissolved and held in solution by the other, depends on the temperature, and the higher the temperature the greater the solubility. Between 900 and 1,000° C., they are apparently completely soluble. It follows from this that when a dissolved pair of metals is cooled slowly, one of them may separate on cooling, if the limiting solubility is reached, and the extent of effective separation may depend on the rate of cooling.

Our second case, that of chemical combination between the metals, is made most evident by the form of the freezing point curve of the possible alloys. A compound of two metals which is stable at a temperature above the melting point of one or both of the metals, shows very clearly on the melting-point curve and acts toward each of the elements just as a new, or third element. Its melting point cannot yet be predicted from any knowledge of the component metals. It may even melt higher than either of the components. Such cases are seen in alloys of aluminum-antimony, in lead-tellurium, etc.

Man first used the metals as he found them; then, as he reduced them from the ores, and finally, when specified requirements became more and more exacting, he not only brought into use previously unused metals, but also greatly modified the old familiar ones. For a harder iron he used steel, a carbon alloy; for a harder steel, or one capable of cutting iron more readily, he added tungsten, nickel, chromium and other metals. For permanent magnets molybdenum was added. for high electrical resistance nickel, chromium, etc., were added, for high electrical resistance and low hysteresis, silicon and aluminum were added; for toughness in springs a little vanadium was used, and for wearing qualities titanium is now introduced. These are only a few of the successful alloying experiments with iron. They will probably be repeated with other metals, such as copper, zinc and aluminum, where the cost of the base metal is not high.

On the other hand, the study of those metals which have not yet advanced to a stage where first-order cost-reduction is impossible, is equally

*From a paper at the convention of the American Brass Founders' Association, May 24, 1911.

†Director of the Research Laboratory, General Electric Co., Schenectady, N. Y.

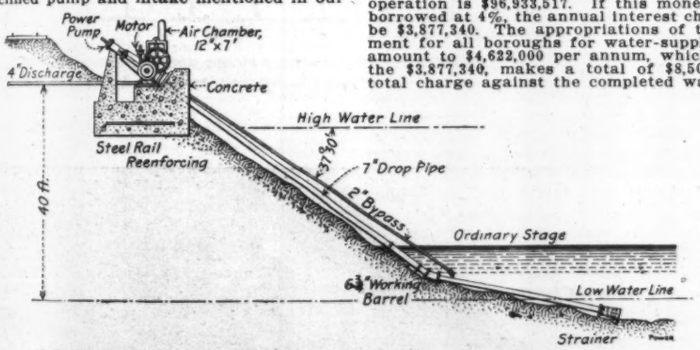
interesting. Consider again, the element chromium. What do we know about it? Is it a workable metal? Can it be hammered or cast? Is it permanent in the air? Is there a considerable possible ore supply? Has the cost of obtaining the metal been reduced to what seems a reasonable rate?

As it is unlikely that such an element will suggest itself for use by men as did copper and iron, it is probable that its properties must first be determined and made known. As a metal, it is only about 15 years old. It is made in the metallic state by reduction of the oxide by metallic aluminum and also by electrolysis of its salt solutions. It cannot yet be produced at a lower cost than that of the aluminum required, and it now sells at about 80 cts. per lb. In the oxide from which it was made, it may be had for less than half this cost, and in its alloys with iron, which are made by direct reduction with carbon; it is sold for 29 cts. per lb. This gives an impression that ultimately, by perfection of metallurgical processes, etc., we may possibly obtain the metal much below 80 cts. per lb. It withstands heat exceedingly well. When pure it melts at very high temperature (Ostwald, about 3,000° C.) and it does not scale when heated red hot in air, as copper and iron do. It is for this reason that it is used in resistance alloys for electric heating devices. It has been plated into metals, and then looks and acts like nickel plate. Doubtless its use will quite rapidly increase in special alloys, as it has already come into use in tool steel.

An Inclined Deep-Well Pump Used to Take Water From a River Having Great Variations in Level.

Years ago we described the use of inclined wells for taking water from beneath the sandy bed of Lake Michigan at South Haven, Mich., and also from beneath the Missouri and Mississippi rivers (see Eng. News, May 11, 1893, p. 452). We are indebted to "Power" of Oct. 17, 1911, for a description of a deep-well pump, with its tube placed on an incline, to take water from a stream having great variations in level. The arrangement described serves as a substitute for mounting a pump on a carriage and raising or lowering both pump and carriage with changes in the river level.

The inclined pump and intake mentioned in our opening paragraph was installed at the power plant of the Colonial Coal & Coke Co., at Prestonburg, Ky., and was described and illustrated by Mr. W. T. Griffith, of that company, in the journal already mentioned. The plant just named is located so far from the river that it was not considered practicable to pipe steam to operate a steam pump on the river bank. This was obviated by using an electric motor. The plan also saves the trouble of moving the pump and breaking and making connections with changes in the river level.



INCLINED DEEP-WELL PUMP AND INTAKE, TAKING WATER FROM THE BIG SANDY RIVER, PRESTONBURG, KY.

In further description of the conditions met and solved by Mr. Griffith we quote from his article, as follows:

> The Big Sandy River is a stream which varies from about 2 ft. of water to 35 ft. at extreme high water; and during the heavy rains of spring and fall the rises often come suddenly. During high water the river carries large quantities of mud and sand which as the river falls is deposited along the banks and on the bars.
>
> The writer conceived the idea of setting a deep-well pump on top of the river bank, at such an angle as to run the drop pipe parallel with the sloping bank of the river and place the working barrel at low water. This would avoid any trouble of priming the pump and at the same time the motor and working head could easily be got at and at all times be out of the way of flood waters.
>
> When this proposition was presented to the different pump manufacturers, none of them could show any good reason why it would not work, but all with one exception seemed to be afraid of it. The worst objection presented was that the sag of the rods against the drop pipe would wear them out. The rods are made of wood and the pipe of iron. The wear is not great and, even if the rods do wear out, the drop pipe is easily accessible and it can be uncoupled and a new rod put in. This wear only comes on the downstroke, as on the upstroke the rods are taut.
>
> The pump installed is a Platt Iron Works, designed for a working head of 151 ft., with a stroke of 24 ins. and a 6¾-in. working barrel. The pump makes 30 strokes per minute. The setting of the working head at an angle necessitated some changes from the regular pattern in order to connect the 15-HP. motor.
>
> To avoid some rock excavation the working barrel was placed above extreme low water but below the average stage, and from the working barrel a suction pipe is carried out into the river and at the end is placed a 100-mesh screen. Should the river deposit silt around the suction or other obstructions gather around the screen, there is provided a 2-in. bypass from the main discharge to the suction, which on being opened will force anything away from the screen.
>
> The pump discharges into a 20,000-gal. tank placed on the hillside 145 ft. above the level of the check valve of the pump. When the pump was first started considerable trouble was caused by fluctuations in pressure. This has been practically overcome by increasing the size of the air chamber, which is now 1 x 7 ft.

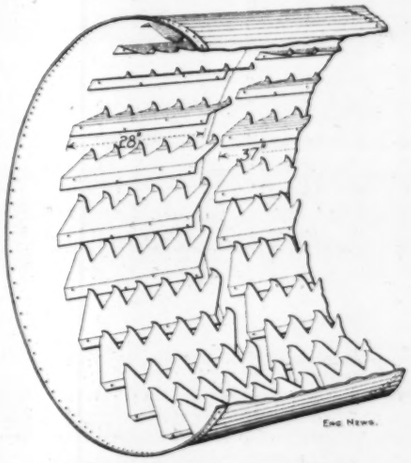
The Water-Works of Greater New York now yield a net profit to the city of $4,782,809 per annum over the interest on its cost, according to a statement prepared last week by Water Commissioner Thompson and presented to Mayor Gaynor. The basis on which this profit is computed is explained by the Commissioner as follows:

> I have received from the Comptroller a statement showing that the total amount of bonds issued for the completed water systems now in operation is $96,933,517. If this money had been borrowed at 4%, the annual interest charge would be $3,877,340. The appropriations of this department for all boroughs for water-supply purposes amount to $4,622,000 per annum, which, added to the $3,877,340, makes a total of $8,500,340, as a total charge against the completed water system for the city and also the running of the department.
>
> Collections last year amounted to $13,283,150, which would show a net profit to the city at the present time on the completed water system of $4,782,809. There have also been issued, in addition to the above, $53,602,000 worth of bonds for the Catskill water supply. This, also at 4% interest, would make a further charge at the present time against water revenues of $2,144,080, which makes the profit above interest on all bonds issued for water purposes at the present moment $2,683,729.70. If the total cost of the Catskill Aqueduct is to be $172,000,000, this would mean that the city has to lay out $119,000,000 more, which, at 4% interest, would amount to $4,760,000 additional. This, under the present revenues, would show a loss of $2,121,270.50.
>
> We may add, however, that the entry of the Catskill supply under high head will make possible very large reductions in the present expenses of the Department. The city is now, we believe, buying water from private water companies at high rates to supply some outlying districts. It is also at very heavy expense for pumping a large part of the supply and this pumping will no longer be necessary when the Catskill water is obtainable at high pressure. Further, the increase in water consumption when the larger supply is available ought to return added revenue to the city if the water is sold through meters and not merely wasted.

A Device for Increasing the Capacity of Rotary Driers for Granular Materials.

A new idea in the design of buckets for rotary driers is shown in the accompanying illustration. A common type of rotary drier for such granular materials as sugar, salt, sand, etc., consists of a rotary cylinder slightly inclined from the horizontal with a number of longitudinal buckets or flights on its inner surface. The material to be dried falls into the drum at the higher end, and as the cylinder slowly revolves the buckets raise some of the material and pour it back again in a thin stream, passing it along a little each time toward the lower end of the drum. The streams of material from the buckets fall through a current of hot air flowing through the cylinder.

In the ordinary design of rotary drier the buckets are made with a straight lip. In the new design, as shown in the illustration, the edge of the buckets is serrated, forming a series of large "saw teeth" on the edge over which the material pours. In this way the effective length of the bucket lip is increased and the granular material is scattered in an open shower instead of falling in a solid sheet. It is claimed that the capacity of a drier of given length and diameter can be increased 10 to 25% by forming the bucket in this way.



Saw-Tooth Flights for Rotary Driers.
(Invented and patented by R. S. Kent, Brooklyn, N. Y.)

The device is the invention of Mr. Robert S. Kent, of 253 80th St., Brooklyn, and was patented March 2, 1909 (No. 914,052). The Hersey Mfg. Co., South Boston, Mass., has the sole rights under the patent for building driers for sugar, salt and granular chemicals. Since May, 1909, when this form of bucket was first put on the market, 50 driers of this type have been put into use in various parts of the country for drying sugar, salt and sulphate of iron.

The Grubstake Movement in Colorado, the object of which was to raise by popular subscription a fund to be used for financing a systematic prospecting project, is described as follows in a recent issue of the Colorado School of Mines "Quarterly":

> In May, 1911, the Denver "Republican" suggested that a fund of $10,000 be raised by popular subscription as a Grubstake Fund, and that with the proceeds of this fund prospectors be sent into the mountains to find a "Second Cripple Creek." The suggestion met with popular support, the amount was over-subscribed, and 34 parties were sent out. The movement was guided by a committee of the Denver Chamber of Commerce, consisting of Max Boehmer, Chairman, Ernest Le Neve Foster, Secretary, and James Doyle. No prospectors were sent to the vicinity of the old and prosperous camps. All were carefully selected men. The preference was given to those who had seen float or veins in some particular region, and were anxious to prospect that district. Only a few prospectors were sent to localities selected by the committee.
>
> Discoveries of pay ore were made in Gunnison, Routt, Jackson, La Plata, Montezuma, Boulder, and Custer Counties. The metals found were gold, silver, lead and copper. A movement is under way to form a Chamber of Commerce Co. to continue the work and to develop the prospects discovered. This grubstake movement has not only resulted in much prospecting on its own account, but it has stimulated many private persons to do likewise.

Model Housing Plans for the Philippines.

By GEO. H. GUERDRUM.*

In the Philippine Islands, coincident with the subject of municipal drainage, municipal water-supply and municipal scavanger service, the no less important branch of house sanitation has received the attention of the sanitary authorities.

In some ways it would appear that in a tropical country, where houses are not erected for protection from cold weather, the sanitary problem would be very much simplified, yet it has developed that in a warm country the increased danger of infection from transmissible disease in a large measure tends to offset any such advantage gained.

Preliminary to the regulation of building operations the following items have been carefully considered: (1) The natural habits and customs of the people; (2) the modes of transmission of diseases most prevalent and most dangerous to the community and known means of prevention.

The national and typical house[illegible] the Philippines is a palm-leaf or grass-[illegible]ed bamboo structure which, outside of the [illegible]s of population, is the type generally used[illegible] while on the outskirts of every town, including [illegible]nila, hardly any other form of house prevails.

*Chief, Division of Sanitary Engineering, Bureau of Health for the Philippine Islands.

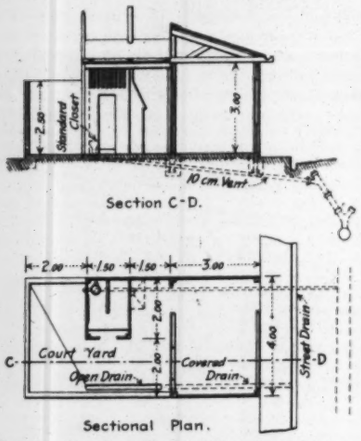


Fig. 1. Simplest Form of One-Story House.

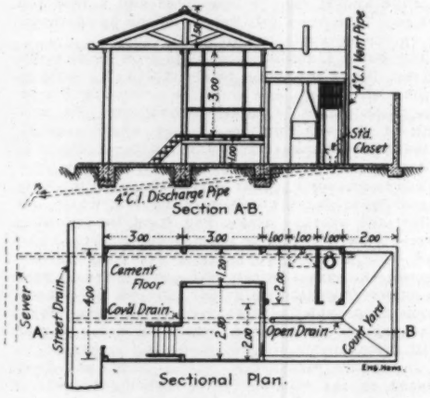


Fig. 2. More Capacious One-Story House Than Shown by Fig. 1.

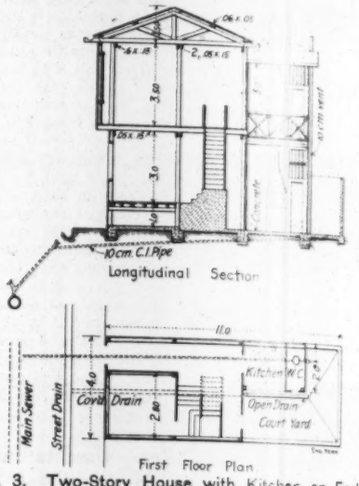
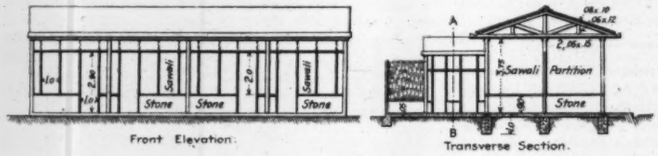


Fig. 3. Two-Story House with Kitchen on Each Floor.
(In a simpler house, there is only one kitchen for both floors.)



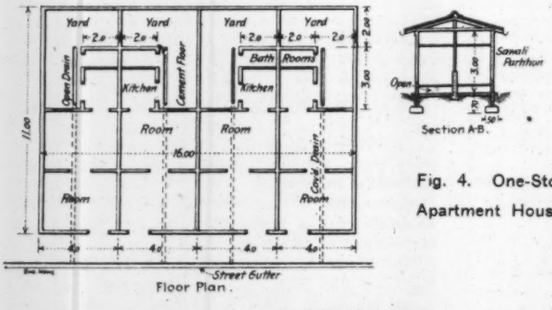


Fig. 4. One-Story Apartment House.

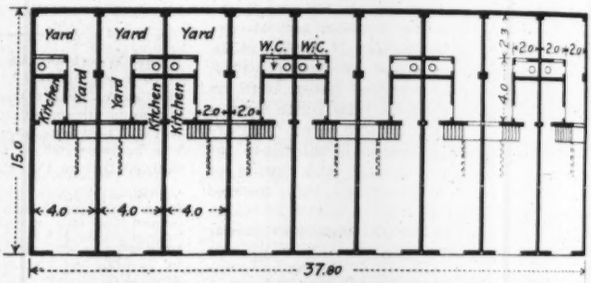
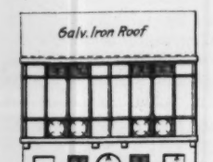
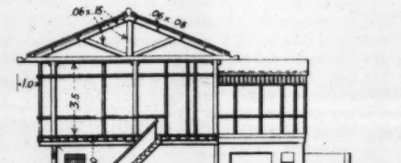


Fig. 5. First Floor of Two-Story House with Nine Apartments on Each Floor, and no Kitchen on Second Floor.





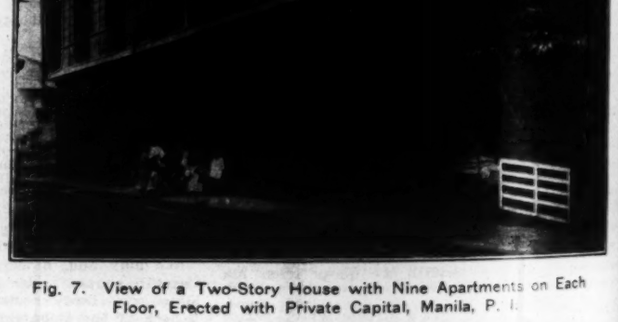
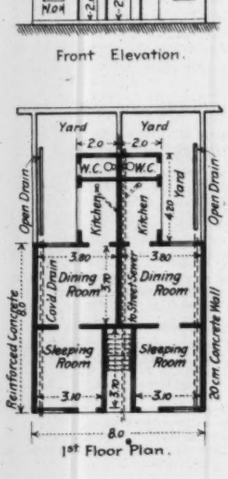


Fig. 7. View of a Two-Story House with Nine Apartments on Each Floor, Erected with Private Capital, Manila, P. I.



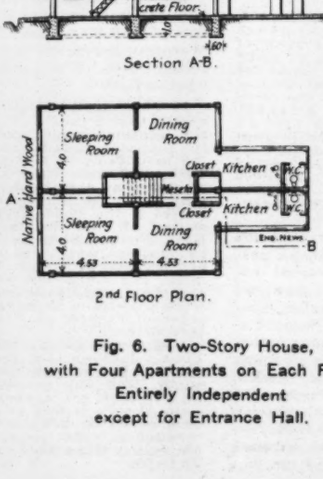


Fig. 6. Two-Story House, with Four Apartments on Each Floor, Entirely Independent except for Entrance Hall.

FIGS. 1 TO 7. PLANS FOR VARIOUS TYPES OF LOW-COST MODEL HOUSES AND APARTMENT HOUSES DEVISED BY THE BUREAU OF HEALTH FOR THE PHILIPPINE ISLANDS.
(Dimensions given in meters.)

With the provision of a municipal water-supply, surface drainage, public comfort stations, and a mild form of building supervision this style of construction has been rendered quite sanitary and will probably be continued in use for a long and indefinite period. (See article by present writer, entitled "A Novel House and Street Sewerage System for Portions of Manila, P. I.," Eng. News, Oct. 6, 1910.)

In the congested districts, however, this form of construction, on account of danger from fires and waste of ground space, cannot be used, and recourse must be had to stronger building materials.

The materials at hand and the congested, disease-spreading conditions confronted a few years ago in Manila have not been encouraging. Unsatisfactory enforcement of existing building regulations, long rows of houses opening into back yards used in common by hundreds of people; lack of kitchen facilities; cooking carried on in clay fire pots stuck around anywhere where temporary protection could be secured from the sun or rain; foul privies, used in common by all tenants and both sexes; lack of drainage, etc., were some of the evils encountered.

Conditions are by no means ideal now, as a house once erected is a very lasting affair and when built on unsanitary lines is difficult to alter; a great advance has, however, been made. The large back yards common to dozens of doors and scores of families are now discouraged.

Common privies used by many families are removed whenever possible and individual water closets for each house connected to the sewer system substituted, or in some cases, removed altogether and contiguous municipally-controlled public convenience stations substituted.

With a view to improving future construction and educating local architects and house-owners of the Philippine Islands in the principles of modern house sanitation a series of house designs has been prepared which is distributed gratuitously to interested parties. One of the keynotes of these plans is unit construction; with the avoidance of tenement-house conditions and evils, such as common toilets, kitchens, yards, etc. The aim has been to make each apartment complete in itself with a separate entrance, kitchen and small yard surrounded by an effective wall. As many units may be constructed as the property will hold.

Fig. 1 shows the smallest type of house which may be erected within the fire limits of Manila, consisting merely of a single-pitched roof over the main room of the house with another small adjoining single-pitched roof in the rear over a small kitchen. In case of a row of these units being erected the roof of the adjacent kitchen would slope the other way, forming a small double-pitched roof over the two kitchens.

If this house is erected in Manila, and if it abuts on a line of the sanitary sewer, it must be connected thereto. Where the house is to be erected in the Provinces, or in parts of Manila where there is no sewer, this cannot be required. The entire floor of the house is paved with concrete, surfaced with cement mortar.

Fig. 2 is a slightly more commodious house, two rooms deep. The kitchens, yards, etc., are similar in every respect.

Successive stages of development are afforded by two-story houses, first with a single kitchen, down stairs, for the two while (Fig. 3) the next stage has a separate kitchen on each floor.

Owing to frequent earthquakes, three-story and four-story frame buildings have not been found satisfactory and for this reason the problem of tall tenements has not to any great extent entered into the sanitary problems of the Philippine Islands.

Fig. 4 shows a design for what are known as mixed material "possessions." These are permitted outside of the fire limits of the larger towns. They are built with a galvanized-iron roof and with wood framing but in order to lessen the cost of erection, the walls are covered with a bamboo matting known as "suali." Each unit of this type of residence can be built for $150.

Fig. 5 is ground plan and Fig. 7 a view of a new building recently erected on Calle San Marcelino. It will be noticed that each apartment is complete in itself, being separated from the adjoining apartments by means of a stone wall without doors or gates. Thirty per cent. of the ground covered by each unit is reserved for light and ventilation. By requiring that these small yards be paved with a 10-cm. (4-in.) layer of concrete, these places are rendered rat proof and impervious to liquid wastes or refuse. In this way plague and cholera, the two most dreaded diseases of the Far East, can find little foothold.

A house erected on Calle Benevides is very much the same as the one shown by Figs. 5 and 7, except that a second kitchen is provided up stairs for independent housekeeping on the second floor.

In order to prevent possible friction between families living independently of each other on the first and second floors, respectively, but using the street entrance in common, a design has been adopted (Fig. 6) in which each unit consists of four apartments, each one separate and distinct in itself.

The various plans adhere very closely to existing local conditions, with the previously-mentioned insanitary features eliminated.

There are many points in common between housing problems encountered in the Orient and those encountered in the United States. While apparently of such widely different characteristics, the human race, in the fundamental requirements in the struggle for existence, shows pronounced traces of similarity.

Inland Waterways and Waterway Projects in France.

One of the greatest authorities in the world on the economics of transportation systems is C. Colson, of France, a distinguished engineer long connected with the French Department of Public Works and a State Councillor of France.

In the "Bulletin of the International Railway Congress" for October appears an article by Mr. Colson reviewing recent waterway traffic and waterway projects in France. In that country, as in the United States, there is at present a great popular propaganda in favor of enormous expenditures by the Government on inland waterway construction and improvement. The Government engineers who study these questions as impartial experts oppose these expenditures. In our issue of March 24, 1910, we reviewed the action taken by the French Government with respect to several ambitious projects for waterway construction. Below we print extracts from the paper by M. Colson, above referred to, which should interest American engineers who follow the current discussion in this country over projects for inland waterways:

The New Canal from the Marne to the Saone.

The mean traffic of this canal has increased from 165,000 tons in 1907 to 199,000 tons in 1908 and to 271,000 tons in 1909. The saving in distance of 180 kilometers (112 miles) by which some 150,000 tons of goods benefit is very nearly the sole advantage resulting from the expenditure of 86 million francs incurred in constructing this extension. The annual charge for interest on that capital and for maintenance may be estimated at 4 million francs, and only 147,600 francs are covered by the tolls collected by the Chamber of Commerce of St. Dizier; accordingly 25 to 30 francs per ton represent the cost to the taxpayers of the saving of 3 to 4 francs effected in the carriage. This difference will evidently become reduced as the traffic grows; but it will have to grow to a very remarkable extent before the transaction will become a profitable one, even if we leave out of consideration the loss incurred by the State by the traffic taken away from the railways with which it has financial relations.

Traffic on the Seine.

The navigation of the Seine was twice stopped in 1910 by floods, once at the beginning and once at the end of the year. The last interruption, which came immediately after the momentary stoppage of the traffic on the Western-State Railway by the strike, largely contributed to the disorganization on that railway.

The facts then observed once more showed how mistaken those are who consider that the development of inland navigation will relieve railways in times of congestion. We have repeatedly shown by means of statistics that at times when railways have great difficulty in dealing with sudden rushes of traffic, the waterways, far from helping them, do not even take their proportionate share of the increase, and prefer to charge higher freights rather than carry more traffic.

The situation which arose in November, 1910, casts a strong light on another side of the question.

During the discussion which arose in the Senate, Mr. Richard Waddington, the eminent chairman of the Chamber of Commerce of Rouen, gave the following summary of the business conditions of that town:

> During November, 1910, the goods to be dealt with amounted to 334,000 tons; the shipping only took 108,000 tons of this, while according to the proportion previously laid down it should have taken 233,000 tons; that is a considerable deficiency which the railways should have dealt with but which was not dealt with at all.

The difference should have been dealt with by the railways! According to the figures given, their normal share of the traffic amounted to 101,000 tons; shipping having failed to deal with 125,000 tons, the railway should have provided for this; it should have provided for 124% more traffic because shipping stopped. Instead of dealing with 400 cars (each 8 to 10 tons) per day, it should have dealt with 900 at Rouen. But 500 cars more per day, allowing about six days for loading, taking to destination, unloading and returning empty, means that 3,000 cars more would have been required for the Rouen traffic. Was the railway to take these cars away from its regular customers, at a moment when the strike had already led to great delays, in order to help the customers of a competing system?

And assuming that a reserve of 3,000 cars was available, were there enough sidings available at Rouen to deal with 900 cars per day instead of 400? The growth of the traffic at that port certainly makes a considerable increase in railway installations desirable. But is it reasonable to give those installations such a size that the railway can double its traffic from one day to the next, if navigation is stopped by ice, by floods or by low water? Is there any business in the world which can afford to be equipped for needs which may exist during a fortnight or a month every second or every third year? Is the budget to be burdened in order to double the installations normally required at Rouen, so as to provide for any stoppage of the inland navigation?

Is it reasonable that those commercial centers which have already received the excessive privilege of only being charged 1 centime for toll for using a way which has cost the State 70 million francs, between Rouen and Paris only, should in addition have railways including not only the equipment necessary for the normal traffic, but also installations in order to duplicate, if necessary, the waterway; installations which would be unproductive nine-tenths of the time but would always be supplied with the stock and staff necessary for needs which will only occasionally arise?

But, it will be said, the Seine floods succeeding the strike is a quite extraordinary coincidence, and everywhere else one has been happy to fall back on waterways when the railway has stopped. Let us now see what happened at Dunkirk, where the canals at that time were in excellent working order. About 40,000 tons of goods had then accumulated at the wharves in consequence of the stoppage of the railway. The different docks then contained about 175 empty barges, more than enough to take all the goods necessary for relieving the pressure. But the barge owners thought it a favorable moment for doubling their freights; instead of 2 francs per ton, the ordinary freight from Dunkirk to Lille, they asked for 4 francs, and similarly in all other cases.

If an owner, more desirous of obtaining freight at once than of profiting by the public disaster, wished to quote a lower rate, the others knew well enough how to prevent him from starting. And as the railway could neither refuse consignments, nor raise its rates, nor increase the normal time within which consignments had to be delivered, merchants, instead of putting up with the demands of the barge owners, brought their goods to the railway, hoping that if the goods were not conveyed, they would at least receive compensation from the railway for the resulting loss.

Unwise Expenditures on Waterways.

Of late we have again encountered the threat of one of those schemes of public works of which the most evident result is the expenditure of public resources on useless enterprises, so that those resources will no longer be available when any real needs arise. The idea of such a scheme seems to-day to have been given up, and this is a subject of much congratulation. Such a scheme was adopted in 1879, and it is due to this and to the extra expenditure resulting that the French debt was increased to 30 thousand million francs, having previously stood at the crushing figure of 24 thousand million francs, which it had reached in 1875, when the sums due in consequence of the terrible war had been paid.

A more modest scheme was drawn up in 1903, and the whole result has been two useless enterprises which for a long time swallowed up the funds available: the canal from Marseilles to the Rhone, the estimated cost of which has already risen from 71 to 81 million francs; and the Canal du Nord, which was estimated to cost 60 million francs, but which now already is sure to cost 80 millions. The characteristic feature of these two ways is that each duplicates an existing way; one of which perfectly meets existing requirements and the other could have been made to do so at much less cost.

It was just at the time when the advantage of lighters hauled on the sea was being recognized everywhere, that it was decided to construct, at great cost, a canal to allow the boats from the Rhone to reach Marseilles by a way much less convenient than the sea. As regards the Canal du Nord, the expenditure incurred could easily have been avoided by doubling the capacity of the existing line of the Nord to Paris by doubling the tunnel, after the locks; and it was only in order to avoid making useless an expensive piece of work, showy in a scheme, that ten years ago less showy but perfectly satisfactory schemes were not adopted.

The Proposed Ship Canal to Paris.

There is, however, one particular scheme which public opinion now seems specially to favor; that is the Paris seaport proposal, which is a well defined idea worthy of consideration. We cannot here examine the different estimates which have been made of the enormous expenditure involved in making such a long and deep waterway and setting into disorder such important existing ways as the Seine and the railway from Paris to Havre, in districts where land is so very expensive. But we will set forth the arguments which make all experts in commercial navigation hostile to the scheme.

The fundamental idea of the canal is to avoid any transshipment at Rouen and to obtain up to Paris the great advantages which ships afford as compared with any other means of carriage. But these advantages only exist when the ship can sail freely and without hindrance on large sheets of water, such as the sea and large estuaries. In a ship canal or in a narrow river which has been canalized, a large ship can only advance with great care and hardly more quickly than a barge properly hauled. It is consequently evident that there is every advantage in using barges, which cost much less per ton of capacity, are much easier to handle, are much less exposed to the risk of running aground, and which do not immobilize, as soon as they stop, an expensive engine together with its staff.

As regards transshipment, this will not be avoided, for it would be impossible to find the land necessary for constructing a seaport at Paris, near enough to the works and shops in order that cargo after unloading can be carted there direct. It will always be necessary, at Clichy or even further from Paris, to transfer the cargo to barges or to wagons in order to take the wines to Bercy, the corn to Corbeil, the coal to Javel, St. Denis, La Villette, etc., and consequently it is much better to effect this transshipment at Rouen.

As regards Paris exports, as they consist chiefly of high-value goods dispatched in small quantities, it is the quick freight service to the point where they are put on board a quick ship which alone interests them.

We therefore think that the notion of a ship canal from Rouen to Paris, no matter whether more or less costly, is based on a wrong commercial conception. The only comparable waterway which exists is the Manchester canal. This is one-third the length, and this by itself makes a radical difference. It ends at a port which is an enormous railway center, and its traffic chiefly consists of the goods which the railways distribute throughout the district, much more than of the goods required for Manchester industries; for it has not succeeded in transferring to Manchester the center of the cotton trade, which remains at Liverpool.

It is hardly doubtful that the canal traffic would be much smaller if Liverpool had abolished the burdensome system of cartage between the port, the warehouses and the stations, which conservatism and the influence of the carriers has retained to this day, and if an interchange station had been created there as at Manchester.

Moreover, the canal has remained a deplorable business from the financial point of view, and this example, far from justifying the Paris seaport scheme, where conditions are far less favorable, on the contrary condemns it. We do not doubt that any one who carefully examines the scheme and who knows the conditions under which shipping is carried on, will arrive at the same conclusion; and this is perhaps the reason why some of its partisans wish that it should be adopted without further investigation.

Notes From Engineering Schools.

CORNELL UNIVERSITY.—The annual meeting of the Cornell Society of Civil Engineers was held at Kalil's restaurant, in New York City, Oct. 17. Officers for the coming year were elected as follows: President, De Forest H. Dixon, '96; Vice-Presidents, General Mario G. Menocal, '88, and Charles H. Baker, '86; Recording Secretary, Malcom A. Rue, '99; Corresponding Secretary and Treasurer, E. A. Truran, '95, Old Grand Central Palace, New York City. These officers, together with the following elected members, constitute the executive committee: William H. Stratton, '88; James B. French, '85; John A. Knighton, '91; Joel E. Wadsworth, '90; Willard Beahan, '78; James H. Edwards, '88.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—A revision of the old courses and the addition of two new courses in the department of mechanical engineering has been proposed by Prof. E. F. Miller. In brief the changes include lengthening the course in hydraulics, more work in electrical engineering, a more complete course in refrigeration, additional studies of the small gas engine and sufficient German to read German scientific periodicals.

It is reported that great success has attended a change in the method of conducting mechanical-engineering laboratory tests, made about a year ago. Students are organized in squads with some one member in charge of each test and responsible for the conduct of the work and the preparation of reports.

A Coal Mine Explosion Nov. 9, at 6 a. m., killed eight men in the Adrian shaft of the Rochester & Pittsburgh Coal & Iron Co., four miles from Punxsutawney, Pa. The bodies of six of the victims were recovered that night by the U. S. Bureau of Mines rescue crew from Pittsburgh.

The Concrete Bridge Failure at Auburn, Cal., on Nov. 4, reported in our issue of last week, was due to the collapse of a timber centering under one of three 140-ft. arches. The first reports as to the number of fatalities were much exaggerated; instead of 16 men being killed, 3 workmen were killed and 3 others injured in the collapse. The bridge comprises three 140-ft. concrete arch spans over one fork of the American River and is to be used for a railway now being built to tap the cement rock quarries beyond the river. Two of the arches had been completed and work was in progress day and night on the concreting of the third and final span, when the centering under this arch collapsed. We have received the following telegram from the Mountain Quarries Co., the owners of the bridge:

The first telegraphic reports of the accident at Auburn were much exaggerated and implied that the whole bridge structure had failed. What actually happened was that the falsework of the third and last span of the bridge failed while the concrete arch was being poured. Owing to the efforts to save lives the wreckage was left in such condition that we have been unable to determine the exact cause of the failure of this falsework. Whether it was due to some latent defect of material or whether something happened which was not noticeable owing to the time of night at which it occurred we cannot as yet determine. The financial loss to everybody concerned is comparatively light, leaving the loss of three lives as the most deplorable part of the accident. The delay at this time of the year, owing to the danger of high water, is also important, but the rain and snowfall in the neighborhood, unless abnormal, will not interfere with the completion of the structure this Fall in accordance with original plans and design.

A Strike of City Refuse Carts in New York City, Nov. 9, and day spread to street sweepers. The Commissioner of Street Cleaning, W. H. began to collect strike breakers began to remove the accumulated bage from the streets. This riots and attacks from the hoodlum ment districts where the inhabitants sympathy with the strikers. creased and only by severe rioting police able to stop it. An order helped the city authorities in preventing the refuse in the streets from becoming a menace. By Nov. 15 the collections were largely resumed and the strikers appeared discouraged. The striking men were all civil-service employees and the city's attitude toward them was repeatedly stated by Mayor Gaynor. By refusing to work they were held guilty of insubordination and could not again enter the department's employ except as the Civil Service Commission put them on new eligible lists. The practical result is that the strikers cannot go back to work so long as there are other suitable men seeking the jobs.

Reinforced-Concrete Accident Statistics will be collected in the State of Prussia, Germany, under government auspices; the Deutsche Ausschuss für Eisenbeton (German Reinforced-Concrete Committee) is to receive the statistical data. An order was issued to all the police heads of Prussia on Sept. 18, 1911, by the Minister of Public Works, directing them to cooperate with the committee "Zentralblatt der Bauverwaltung," Nov. 1, 1911). The order was accompanied by general instructions for procedure, and a list of experts who give their services to the committee as investigators. When an accident to a reinforced-concrete structure comes to the notice of the police (or the building bureau, which in Prussia is part of the police administration), an expert may be chosen from this list to investigate the causes and circumstances of the accident, and in case the accident leads to judicial inquiry the public prosecutor will call for the aid of such expert. The central office of the committee is to be notified in each case, and all reports of experts will be collected there. Publication of findings will be made at the discretion of the committee. It is to be noted that the committee is a semi-official body, having been formed at the instigation of the government and occupying an office in the building of the Ministry of Public Works.

A Board to Examine the Wreck of the "Maine," has been appointed by the President. This board, consisting of army and navy officers, is to proceed to Havana, examine the exposed wreck and report all possible data it can gather, particularly as to the cause of the destruction of the vessel. The personnel of the board is Rear Admiral C. E. Vreeland, U. S. N., Chief Naval Constructor R. H. Watt, U. S. N.; Col. W. M. Black, Engineer Corps, U. S. A.; Commander C. F. Hughes, U. S. N. and Commander Joseph Strauss, U. S. N.

Eleven Socialist Mayors in Ohio, a socialist mayor and majority of the Common Council of Schenectady, N. Y., a socialist mayor at Crookston, Minn., and socialist gains in various other cities, as well as in votes for State officers, were among the notable results of the election on Nov. 7. The ten Ohio cities indicated were Barberton, Canton, Cuyahoga Falls, Fostoria, Lima, Lorain, Martin's Ferry, Mount Vernon, Salem, Saint Mary's and Toronto. The campaign in Schenectady was led by Rev. George R. Lunn, editor of a socialist weekly called "The Citizen," on a campaign for a municipal paving plant, a reduction in the price charged for gas, a curtailment of the city payrolls, etc., and like reforms.

A School of Public Administration has been started by the Bureau of Municipal Research, of New York City, with funds provided by Mrs. Mary Harriman, widow of the late E. H. Harriman. For the training of secretaries of municipal research bureaus and experts in various municipal operations, $40,000 per year has been promised for five years. The work will begin in New York City, when there is ready opportunity on account of the Board of Estimate's inquiries into the administration of schools, health work, hospitals, charities, contracts, payrolls, etc. The students will preferably be college graduates, expert accountants, school superintendents, etc., who will be put to work beside experts in making searches into the operations of the departments and offices under scrutiny. It is expected that the men will have studied the theory of the work so that the school may deal with the practical mat-

ters of budget estimates; charter drafting and explaining; court records; tests of milk inspection and physical examination of school children; school and health problems and management; standardization of salaries, contracts, specifications; assessing and collecting taxes; preparing handbooks on administrative practice; reporting proceedings and preparing public statements.

The Commission Plan of Government for Salt Lake City was adopted by popular vote on Nov. 7.

The Commission Plan of City Government was an issue in a number of Massachusetts cities at the election on Nov. 7. Two cities voted against the plan, two for it and one for a plan which closely approaches commission government although providing for a mayor and a small single-bodied council. The city of Cambridge went against the plan by a majority of nearly a thousand out of some twelve thousand votes, notwithstanding the vigorous campaign conducted by Prof. Lewis J. Johnson and others, as noted briefly on page 545 of our issue of Nov. 2.

Chelsea, which after the disastrous fire that occurred a few years ago, put its city administration in the hands of a board of control, voted to abolish the board and to substitute therefor a mayor, at a yearly salary of $1,500, and nine aldermen, at $500 a year, four of the aldermen to be chosen at large and five by wards. An alternative plan, provided for a commission consisting of a mayor at $1,200 a year and four councilmen at $1,000 a year. This plan received only 1,731 votes against 1,961 for the plan adopted. The plan adopted, however, included the initiative, the referendum and the recall—all features common to the commission plan but, of course, perfectly capable of separate adoption. The Chelsea plan adopted included what we believe is a new feature in city government although a reversion of type in Massachusetts, namely, a provision for public meetings of voters.

Lawrence voted to abandon its present charter (5,027 to 2,214) which provides for a mayor, six aldermen and 18 common councilmen, besides a school committee of 12, and voted to substitute a mayor, four aldermen and a school committee consisting of the mayor and four elected members besides. This scheme, which we understand to be the commission plan, was carried by a vote of 6,077 in its favor against 1,858 for a larger council and a larger school committee.

Lowell voted 6,856 to 5,562 for a new charter which provides for a council and school committee like the one declared for at Lawrence.

Pittsfield voted to retain its present form of government practically unchanged instead of adopting either a commission scheme similar in membership of council and school committee to that just mentioned under Lawrence, or a council of seven members elected by wards and a school committee made up of the mayor and seven others.

The Right of a Patentee to fix the resale price of a patented article has been upheld by Judge A. C. Coxe, of the U. S. Circuit Court, Southern District of New York, in the case of the Waltham Watch Co. against C. A. Keene, of New York City. A demurrer filed is over-ruled in the following tems:

> To put a concrete case, is a retailer who purchases from the complainant a "Riverside movement," with instructions not to sell the same for less than $25, liable in equity if he sells for less than that sum?
>
> I think the question must be answered in the affirmative. Many of the authorities have gone much further, sustaining the right of the owner of a patent to impose conditions upon those who seek to use his monopoly. (Heaton Peninsular Co. vs. Eureka Co., 77 Fed., 288; Victor Talking Machine Co. vs. The Fair, 123 Fed., 424; Crown Cork & Seal Co. vs. Standard Brewery, 174 Fed., 252.) See also Cortelyou vs. Johnson, 146 Fed., 933, indicating the opinion of the writer as to the limits within which contributory infringement should be confined.

This case is especially interesting in view of the recent decree of Judge J. N. Killetts in the compromized suit of the U. S. Attorney General against the so-called "Incandescent Electric Lamp Trust" (Engineering News, Oct. 19, 1911). There the practice of fixing the resale price of an incandescent electric lamp was forbidden as a practice serving to restrain trade.

The Volatilization of Creosote from Preserved timber has been studied by the U. S. Forest Service, and is the subject of Circular 188, just issued. To determine the relative values of various fractions of coal-tar creosote in protecting piling, 48 specimens of sap loblolly pine were treated with various fractions and allowed to stand open piled in the laboratory at a temperature of from 60° to 80° F. for two months or longer. They were weighed immediately before and after treatment and at least once a week thereafter. Five fractions were obtained by redistilling a good commercial grade of coal-tar creosote. The distillation limits for these five fractions were as follows: 0-205°, 205°-250°, 250°-295°, 295°-320°, and above 320°. The lighter fractions lost more than the heavier ones, and the losses for the first three fractions were much greater than for that of the commercial creosote containing all fractions. These losses were not due to loss of moisture in the wood.

From these experiments it is concluded that the lighter fractions of creosote, when separated by distillation and injected into sap loblolly pine, will volatilize more readily than when combined in the original creosote. This is explained by the theory that the lighter fractions in the outer portions of the wood volatilize first and leave the heavier fractions, which plug the cells and prevent the volatilization of the lighter fractions of creosote in the interior of the specimen.

Of the Manufacturing Industry of the United States, 80% is under control of corporations. A preliminary statement classifying the statistics of manufactures according to the character of ownership as reported for the Census of 1910 was issued Nov. 8 by Census Director Durand.

The statistics are framed to include all factories with a product of $500 per year or more. Between 1904 and 1909 the number of establishments operated by corporations increased by 36%, the number of wage earners employed in them by 29.5%, and value of products by 49.9%. For all other forms of ownership combined the number of establishments increased during these five years by 20.5%, the average number of wage earners increased only 0.4%, and the value of products 11.3%.

The comparative summary for the United States, 1909 and 1904, follows:

Character of ownership.	No. of establishments.	Average No. of wage earners.	Value of products, 1 = $1,000,000
All industries:			
1909	268,491	6,615,046	$20,672
1904	216,180	5,468,383	14,793
Individual:			
1909	140,605	804,883	2,042
1904	113,946	755,923	1,702
Per cent. increase.	23.4	6.5	19.9
Firm:			
1909	54,265	794,835	2,184
1904	47,934	841,242	2,132
Per cent. increase.	13.2	5.5	2.4
Corporation:			
1909	69,501	5,002,394	16,341
1904	51,097	3,862,698	10,904
Per cent. increase.	36.0	29.5	49.8

Personals.

Mr. Palmer C. Ricketts, M. Am. Soc. C. E., President of Rensselaer Polytechnic Institute, who was operated upon for appendicitis about a fortnight ago, is now progressing favorably.

Mr. H. C. Bixler, Trainmaster of the Pennsylvania R. R., at New York City, has been promoted to the position of Assistant Superintendent of the Philadelphia Terminal Division, at Philadelphia, Pa., of the same railway.

Mr. L. A. Magraw, Assoc. Am. Inst. E. E., formerly Engineer with the Westinghouse Electric & Manufacturing Co., of Pittsburgh, Pa., has been appointed Chief Engineer of the Central Power Co. of Georgia, at Macon, Ga.

Mr. Howard B. Clark, M. Am. Soc. M. E., has resigned from the firm of Flaherty & Clark, Consulting Engineers and Contractors, New York City, and is now the Eastern representative of the McNaull Boiler Mfg. Co., of Toledo, Ohio.

Mr. W. T. Hall, formerly Assistant Superintendent of the Houston & Texas Central R. R., at Houston, Tex., has been promoted to the position of Superintendent of the same division at Ennis, Tex., succeeding Mr. M. Sheehan, resigned.

Prof. Peter Schwamb, M. Am. Soc. M. E., Director of the Mechanical Laboratories and Professor of Machine Design at the Massachusetts Institute of Technology, has retired from active work after 31 years as an instructor at his alma mater.

Mr. F. L. Burckhalter, formerly Division Engineer of the Southern Pacific Ry., at Los Angeles, Cal., has been promoted to District Engineer of the newly created Shasta and Portland Division of the same railway, with headquarters at Portland, Ore.

Mr. Walter H. Evans, formerly Superintendent of Track and Roadway of the Indiana Union Traction Co., at Anderson, Ind., has been appointed Manager of the motor gear department of the Edgar Allen American Manganese Steel Co. with headquarters in Chicago, Ill.

Mr. Milan V. Ayres, formerly Electrical and Mechanical Engineer of the Boston & Worcester Street Ry., and more recently with the Rockland Light & Power Co., Nyack, N. Y., has been appointed Chief Engineer of the Mobile Light & Power Co., of Mobile, Ala.

Mr. T. W. Younger, formerly Assistant Superintendent of the Southern Pacific Ry. Lines in Oregon, at Roseburg, Ore., has been appointed Superintendent of Motive Power of the newly created Shasta and Portland Division of the Southern Pacific Ry., with headquarters at Portland, Ore.

Mr. D. W. Campbell, formerly Assistant General Manager of Maintenance and Operation of the Oregon Railway & Navigation Co., at Seattle, Wash., has been appointed General Superintendent of the newly created Shasta and Portland Division of the Southern Pacific Ry., with headquarters at Portland, Ore.

Mr. W. H. Cade has resigned as Chief Irrigation Engineer of the U. S. Indian Service, Department of the Interior, to engage in private practice in partnership with Mr John H. Quinton, M. Am. Soc. C. E., Consulting Engineer of the U. S. Reclamation Service, with offices in the Wright & Callender Bldg., Los Angeles, Cal.

Mr. S. B. Way, Assoc. Am. Inst. E. E., formerly Superintendent of the Union Electric Light & Power Co., of St. Louis, Mo., has been made Manager of the Milwaukee Lighting Co., Milwaukee, Wis. Mr. K. H. Hansen, Assoc. Am. Inst. E. E., formerly Assistant Chief Engineer of the Union Electric Light & Power Co., succeeds Mr. Way as Superintendent of the same company.

Mr. Morris Knowles, M. Am. Soc. C. E., Consulting Engineer, of Pittsburgh, Pa., has been engaged by the Alabama Coal Operators' Association to undertake an investigation of the coal mining camps of the companies represented in the organization. The survey outlined includes a study of the housing conditions, sanitary features of water supply, sewage and garbage disposal, etc. Mr. Maurice R. Scharff, Assistant to the President of the Massachusetts Institute of Technology and a graduate in sanitary engineering of that institution, has been selected as Mr. Knowles' assistant.

Sir William H. White, Past President Inst. C. E., has been awarded the John Fritz Medal for 1911, for notable achievements in the field of naval architecture. The presentation will be made on Nov. 17 at the Annual Dinner of the Society of Naval Architects and Marine Engineers by Mr. Onward Bates, Past President of the American Society of Civil Engineers. Sir William Henry White was born in 1845 and educated at the Royal School of Naval Architecture of Great Britain. He entered the Constructive Department of the British Admiralty in 1867, rising to the rank of Chief Constructor in 1883. From 1883 to 1885 he organized and directed the warship building department of Armstrong & Co., of Newcastle. For the seven following years he was Director of Naval Construction and Assistant Controller of the Royal Navy, during which period he was the responsible designer of all the British warships then building. In 1902 he resigned this office because of ill health and was awarded a special grant of money by vote of Parliament in recognition of his exceptional services to the navy. He is a Past President of the Institution of Mechanical Engineers and an officer and member of many learned and professional societies. He is the author of several books and papers on naval architecture.

Obituary.

Victor R. Gibson, a mining engineer of St Louis, Mo., died in that city on Nov. 7. He was born in St. Louis in 1854.

Leonard Bullion, a metallurgist with the Carnegie Steel Co., of Pittsburgh, Pa., died on Nov. 7. He was born in Dunfermline, Scotland, in 1855, and came to this country when a lad.

John L. Lewis, founder and former President of the Lewis Foundry & Machine Co., of Groveton, Pa., died at his summer home in Erie, Pa., on Nov. 6, after a week's illness, from pneumonia. He was 73 years old.

William H. Taylor, Master Mechanic of the New York, Susquehanna & Western R. R., at Stroudsburg, Pa., died from apoplexy on a train in the Hoboken terminal of the Delaware, Lackawanna & Western R. R., on Nov. 10.

Charles Henry Israels, M. Am. Inst. Archs., of the firm of Israels & Harder, Architects, New York City, died at his home in Yonkers, N. Y., on Nov. 13. He was born in New York City in 1865. He studied architecture in New York and Paris. As a member of the firm of Israels & Harder, Mr. Israels designed many notable buildings in New York City, including the Hudson Theater and the Arlington and Holland hotels. He was for three years a member of the executive committee of the Architectural League of New York, and was a charter member of the Municipal Art Society.

Charles A. Reed, of the firm of Reed & Stem, Architects in charge of the design of the new Grand Central Station, New York City, died at his home in New York City on Nov. 13. He was born in Avon, N. Y., in 1857, and attended Massachusetts Institute of Technology for a short time. His professional work commenced in St. Paul, Minn., in 1882. He soon specialized in railway station work and was architect for stations on the Great Northern, Northern Pacific, Chicago Great Western and Norfolk & Western Rys. Besides well known railway buildings in Seattle and Tacoma, Wash., Norfolk, Va., and other cities, he was the designer of several public buildings in St. Paul.

George A. Treadwell, a mining engineer and promoter, died in New York City on Nov. 11. He was born in Maine and educated in the public schools of that state and at Yale University. In 1867 he was Superintendent of the famous Vulture Mine in Arizona, and constructed there the largest stamp mill which had been built up to that time. Here he succeeded in working successfully some very low grade ores. Afterward he spent a long period in Europe and was for several years lecturer on assaying and metallurgy at the Dexter School of Mines in London. Returning to this country he went again to Arizona and became interested in the development of the copper deposits in the Verde Copper Belt as President of the George A. Treadwell Mining Co.

Engineering Societies.

COMING MEETINGS.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS.
Nov. 17-18. Annual meeting at Canton, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

ENGINEERING ASSOCIATION OF THE SOUTH.
Nov. 17-18. Annual meeting at Atlanta, Ga. Secy., H. H. Trabue, Carnegie Library, Nashville, Tenn.

NEW JERSEY SANITARY ASSOCIATION.
Nov. 24-25. Annual meeting at Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 4. Annual meeting at New York City. Secy., William H. Ross, 154 Nassau St., New York City.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Dec. 4-9. Annual meeting at Havana, Cuba. Secy., Wm. C. Woodward, Washington, D. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 5-8. Annual convention at New York City. Secy., Calvin W. Rice, 29 West 39th St., New York City.

NATIONAL IRRIGATION CONGRESS.
Dec. 5-9. Annual session at Chicago, Ill. Secy., Arthur Hooker, 214 Hotel La Salle, Chicago, Ill.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 11-13. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 12-14. Annual convention at Washington, D. C. Secy., Glenn Brown, the Octagon, Washington, D. C.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 20-22. Annual meeting at Washington, D. C. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 27-29. Annual meeting at St. Paul, Minn. Secy., J. B. Davidson, Ames, Iowa.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27-Jan. 3. Annual meeting at Washington, D. C. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
Jan. 6. Annual meeting at Seattle, Wash. Secy., Joseph Jacobs, 803 Central Bldg., Seattle, Wash.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.
Jan. 9. Annual meeting at New York City. Secy., J. R. Wemlinger, 13 Park Row, New York City.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
Jan. 16. Annual meeting at Pittsburgh, Pa. Secy., Elmer K. Hiles, 2511 Oliver Bldg., Pittsburgh, Pa.

St. Louis Railway Club.

At the meeting of Nov. 10, Prof. W. F. M. Goss, of the University of Illinois, gave an address on "What the University of Illinois is Doing and Planning to Do of Interest to the Railroads."

Association for Standardizing Paving Specifications.

The date of the third annual meeting has been changed to Jan. 8-13. The meeting will be held at the Hotel Grünewald, New Orleans, La. Mr. J. B. Hittell, 5917 Winthrop Ave., Chicago, Ill., is secretary.

Central Railway Club.

At the regular meeting of Nov. 10, in Buffalo, N. Y., Mr. F M. Whyte presented a paper on "The Distribution of Instructions and Information in Large Industries."

Society of Engineers of Eastern New York.

At the opening meeting of the season held at Troy, N. Y., Nov. '15, Mr. C. D. Smith, Engineer of the U. S. Bureau of Mines, Pittsburgh, Pa., gave a lecture on "Producer Gas Apparatus and its Relation to Fuel Economy."

American Society of Engineer Draftsmen.

At the regular monthly meeting in the Engineering Societies' Bldg., New York City, Nov. 16, papers will be presented on "Construction Work West of the Missouri River," by Walter Dalton, and on "Comprehensive Drafting and Lettering," by Charles W. Reinhardt, Chief Draftsman, Engineering News.

Institute of Operating Engineers.

A bulletin to be issued on Nov. 20, will give an announcement of special rates which have been secured from various correspondence schools for the student members of the Institute.

A course of lectures on power plant accounting will be given before the New York branch during the winter. At a meeting held Oct. 20, it was decided that this branch shall be named after Mr. J. C. Jurgensen, the founder of the Institute.

Ohio Society of Mechanical, Electrical and Steam Engineers.

The program of papers for the twenty-fourth meeting to be held Nov. 17-18, at the Hotel McKinley, Canton, Ohio, includes the following:

"Superheated Steam," Embury A. Hitchcock, Columbus, Ohio; "Fusing Temperature of Coal Ash and its Relation to the Rate of Combustion," E. G. Bailey, Boston, Mass.

This meeting marks the tenth anniversary of the founding of the society.

American Institute of Consulting Engineers.

Nominations for members of the council to be voted for at the annual meeting, Jan. 16, in New York City are as follows: Geo. F. Swain, Cambridge, Mass. (for one year); Alfred Noble, New York City; Edward C. Shankland, Chicago, and Frank J. Sprague, New York City, (for three years).

An informal dinner meeting will be held Dec. 1 at the Aldine Club, Fifth Ave. and 23d St., in New York City.

Cleveland Engineering Society.

At the regular meeting of Nov. 14 a symposium of papers on the subject of water purification was presented as follows: "Purification by Filtration," Mr. R. Winthrop Pratt, Cleveland, Ohio; "Purification by Chemicals, and Interpretation of Water Analyses," Dr. R. G. Perkins, Western Reserve Medical College; "Purification by Ozone," Mr. R. M. Leggett, The National Air Purifying Co., Ann Arbor, Mich.; "Purification by Electricity," Mr. D. D. Vincent. The Electra Pure Water Co.

American Society of Mechanical Engineers.

Nominations for officers to be elected at the coming annual meeting, Dec. 5, are as follows: For President, Alex. C. Humphreys; for Vice-Presidents, Wm. F. Durand, Ira N. Hollis and Thos. B. Stearns; for Managers, Chas. J. Davidson, Henry Hess and George A. Orrok; for Treasurer, Wm. H. Wiley.

The following are the nominations for officers of the Gas Power Section: For Chairman, H. J. K. Freyn; for Members of Executive Committee, I. E. Moultrop (to serve five years); Max Rotter and H. F. Smith (to serve one year).

American Civic Association.

The seventh annual convention will be held in Washington, D. C., Dec. 13-15. The President, Mr. J. Horace McFarland, of Harrisburg, Pa., will take as the subject for his address, "Are National Parks Worth While?" An effort will be made to emphasize the need for a federal bureau of national parks. The importance of such a bureau was pointed out by President Taft in his last annual message. There will be in connection a display of national park views.

Among the addresses to be given in the City Planning sessions is one by Major [illegible]n. V. Judson, Engineer Commissioner of the District of Columbia, on "Washington, the Model City." Some of the meetings will be devoted to a consideration of the smoke and billboard nuisances. Mr. LeRoy Boughner, of Minneapolis, will describe the results secured in that city in transforming vacant lots into vegetable and flower gardens, and Dr. John Quincy Adams, of New York, will explain the functions of municipal art associations.

Brooklyn Engineers' Club.

Unusual action was taken at the club's meeting of Nov. 9, by passing on a resolution requesting Gov. John A. Dix to appoint an engineer to the New York City Public Service Commission, when the next vacancy occurs (Feb. 1, 1912). In discussing the resolution, it was pointed out by referring to specific recent cases that administrative offices requiring an engineer's training are usually filled by lawyers or politicians. The resolution was carried unanimously, and the officers of the club subsequently forwarded a copy to the Governor.

Mr. George A. Orrok, of the New York Edison Co., read a paper describing the Hales Bar hydraulic power plant of the Chattanooga & Tennessee River Power Co.

Nominations for club officers for the coming year were announced. The nominees for president and secretary are W. T. Donnelly and Joseph Strachan. The annual meeting will be held Dec. 14.

New England Water Works Association.

The first of the monthly meetings for 1911-12 was held at the Hotel Brunswick, Boston, on Nov. 8. The usual lunch was followed by two papers. The first paper, which with discussion is reported elsewhere in this issue, was on dual water-supplies for municipal purposes, and was submitted jointly by Prof. Wm. T. Sedgwick, of Boston, and Mr. H. P. Letton, of Trenton, N. J. The second paper, by Mr. H. K. Higgins, of Boston, described in detail experiences of the author while installing municipal water-supplies in the Panama Canal Zone. The paper also included a lengthy abstract of a report on filtration processes, with a recommendation for mechanical filters. Mr. Robert Spurr Weston suggested that the Panama water was a fit subject for treatment along sewage purification lines in order to oxidize and filter out organic matter. President Allen Hazen suggested that the high iron contents of the Panama water suggested a treatment that would precipitate the iron, and be followed by intermittent filtration.

Speaking on quite another subject, Prof. W. T. Sedgwick stated that advance proofs of a further report on typhoid fever in Washington, D. C., made by the U. S. Public Health and Marine Hospital Service completely exonerates the water-supply and filtration plant.

President Hazen announced that a red hot subject had been decided on for the December meeting—Material for Service Pipes.

American Society for Promoting Efficiency.

The organization of a society with the above name is now under way. The first meeting for the purpose of organization is to be held in New York City in December, 1911. An organizing committee has been appointed to select the charter membership to take part in this meeting.

The object of the society, as stated in the tentative draft of the constitution, is "to promote efficiency in commercial and industrial enterprises of all kinds, including public service corporations." It is planned to establish a permanent headquarters for the use of members and committees, to appoint special committees to establish definite standards [of efficiency?—Ed.] for each industry, to collect a comprehensive library of business, to hold meetings for the promotion of acquaintance and interchange of thought and to publish the papers presented at these meetings.

Among the members of the organizing committee are the following: T. C. du Pont, Wilmington, Del.; P. W. Gates, Chicago, Ill.; Henry R. Towne, New York City; Harrington Emerson, New York City; John Hays Hammond, New York City; Alexander C. Humphreys, New York City; William Kent, New York City; John F. Wallace, New York City; J. G. White, New York City; Edmund J. James, Champaign, Ill.; Herman Schneider, Cincinnati, Ohio; Charles B. Going, New York City, and Charles Kirchhoff, New York City.

The secretary is Mr. H. F. J. Porter, 1 Madison Ave., New York City.